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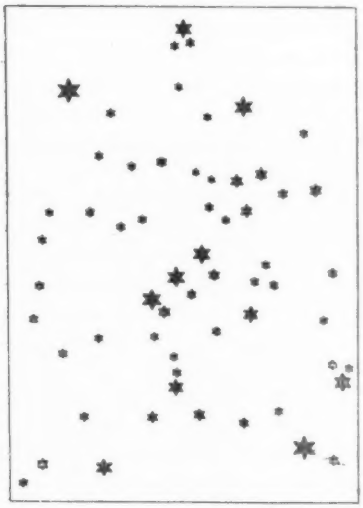
THE GREAT NEBULA IN ORION.

H. C. WILSON.

The finest nebula in all the heavens, at least in that part of the sky which is visible to our latitude, is the great nebula in the Sword of Orion. The constellation of Orion is a conspicuous winter constellation, which doubtless all of our readers have noticed many a time during the past three or four months. It consists of a rude rectangle of bright stars, with a belt of three bright stars, through the middle and hanging from this a line of fainter stars called the Sword or Dagger. The naked-eye stars of the constellation are shown in the accompanying cut. On a clear night anyone with good eyesight can see that the middle star in the sword is surrounded by a nebulous haze. An opera-glass shows this very plainly and with a small telescope what seems to the eye to be a single star is broken up into a group of several stars surrounded by a bluish green haze.



THE CONSTELLATION OF ORION.

This nebula appears to have been first seen by Cysat of Luzerne in 1618. Galileo failed to see it, although he made a map of this region of Orion containing 400 stars. The earliest drawing of the nebula is given by Huyghens in his *Systema Saturnium* published in 1659. Since that time this object has been more studied than perhaps any other in the sky. The wonderful details of its structure have led many observers to attempt to depict them. Numerous drawings have been published and have been carefully compared, to see if they would give any evidence of change in the form or details of the ne-

bula. It is very difficult, however, to make an accurate drawing, especially where many of the details are almost at the limit of vision. If one compares the drawings made by different observers at about the same time he will hardly be able to recognize them as pictures of the same object. Professor E. S. Holden in his "Monograph on the Central parts of the Nebula of Orion" published as an appendix to the Washington Observations, 1878, has given reproductions of a large number of drawings by the most eminent astronomers of the past two centuries. These vary very greatly, and although Professor Holden thinks that there is evidence of some changes in the brightness of certain parts of the nebula, the great differences are the result of personality, incorrect drawing and differing instruments, and on this account grave doubts are thrown upon conclusions drawn from them.

Photography, although it has some faults peculiar to itself, gives a means of depicting the delicate details of nebulæ far more accurately than can be expected of the best drawings. It is free from personal error, except as the latter may affect the development of the sensitive plate, and photographs taken with very different telescopes, different sensitive plates, and developed by different methods show essentially the same details. The one defect is that the contrast between bright and faint portions is heightened, so that, if there are very great differences in brightness, the extremes cannot be shown upon the same photograph. This defect is quite marked in all the photographs which we have seen of the nebula of Orion; when the central, bright part is shown the outer portions are lost, and *vice versa*, when the exposure and development are sufficient to show the very faint parts the details of the center are lost because of over-exposure and over-development.

The first photograph of the Orion Nebula, and this was the first of any nebula, was taken by Dr. Henry Draper, at Hastings, N. Y., on the night of Sept. 30, 1880. It was taken with a refracting telescope of 11 inches aperture, the exposure lasting fifty-one minutes. It showed about what may be seen in the first photograph presented in the frontispiece of this number of POPULAR ASTRONOMY. In March of the following year Dr. Draper secured another photograph with an exposure of 104 minutes, showing stars down nearly to the fifteenth magnitude.

In 1882 and 1883 Mr. Common, in England, obtained a number of excellent photographs of the nebula with a 37-inch reflecting telescope, for which he was awarded the Medal of the Royal Astronomical Society. Quite recently he has obtained still better results with his new 5-foot reflector.

The best photographs which have been reproduced for publication thus far, are those obtained by Mr. Isaac Roberts, in England, with a 20-inch reflector. A series of nine photographs, with exposures varying from 5 seconds to 3½ hours duration, was reproduced by photogravure in *Knowledge*, May 1, 1889. Mr. Roberts' reflector has a comparatively short focal length, only 100 inches, so that the angular aperture is large and the light is concentrated upon a small image. This makes the instrument very effective for the particular work for which it was designed.

The photographs, which we present in the frontispiece of this number, were taken with a refracting telescope of 8¼-inches aperture, and 109 inches focal length. It was originally designed as a visual telescope, and a third lens was afterward added to the objective, correcting it for the photographic rays of light. A guiding telescope, of 5 inches aperture and the same focal length with the larger one, is rigidly attached to the latter, and the observer, while the exposure is being made, looks through this at some star, in or near the object to be photographed. This star is kept continually at the intersection of two cross wires of coarse spider web. Whenever it begins to deviate from this position, either from irregularities in the driving apparatus or the constantly changing atmospheric refraction, the observer at once brings it back by means of adjusting screws which move the two telescopes together. In this way the exposure can be prolonged indefinitely, *i. e.*, while the object is above the horizon. For objects north of the equator too, the construction of the mounting is such that the telescope cannot pass the meridian without being changed in declination.

Our photograph No. 1 was taken on the night of Nov. 6, 1893. The exposure lasted one hour, but the plate was not fully developed so that it shows no more of the nebula than other plates which we have given exposures of only 15 minutes. In order to give the reader an idea of the scale of the picture let me say that it takes in the row of three naked eye stars in the Sword of Orion. The group of stars at the top of the picture form one naked eye star *a*, the group at the bottom another *c*, and the nebula with its involved stars the middle one *b*. All the pictures are inverted, so as to give the telescopic view.

The first thing which catches the eye of an observer on looking through a telescope at this nebula is a group of four bright stars, commonly called the Trapezium, in its midst. In the photograph these stars are so over-exposed that they run together and form a single bright patch in the nebula. The row of three bright stars,

just above and to the right of the brightest part of the nebula, will be easily recognized by those familiar with its telescopic appearance. Another conspicuous feature is the great dark opening in the right side, likened by Herschel, I think it was, to a fish's mouth. The brightest part of the nebula is approximately square except for the opening on the right side, and is broken up into cloud-like patches. Outside of this the tendency of the nebulosity is toward the form of streamers curving away from the central portion. But the reader can see these details better than I can describe them, and I must not take up the space.

Photograph No. 2 was taken on the night of January 25, 1892, with an exposure of two hours. In this the details of the brightest portion are lost, although the original negative shows most of them, and the extent of nebulosity is greatly increased. Details are brought out and given definite form which can be traced with difficulty in a telescopic view. It is hard to say which are the most interesting, the great double curves up to the right, the mass of irregular curves to the left, or the detail about the star just below and to the right of the central portion. Traces of nebulosity appear about the group ι at the bottom of the picture.

Photograph No. 3 was taken on the nights of Feb. 5 and 6 of this year, the total exposure being 9 hours. This brings out a very great extension of the nebula, so that the upper and lower groups of stars are involved. There can be no doubt, I think, that the two nebulæ around ϑ and ι are parts of one greater nebula. The curious convolutions of the upper portions of the nebula remind one very much of the smoke rising from a great conflagration. The dark notch in the upper part of the lower nebula and the lanes through it are very strange and interesting. At first sight the appearance of this nebula seems quite different from that of the great nebula, but on closer inspection the characteristic curves and bright patches of the other will be recognized.

Now I know that some readers have been asking what the straight lines are which run out of the bright stars. Let me say that once during the exposure the driving clock ran down and before the plate could be covered the stars had trailed part way across the plate, the bright ones only having sufficient intensity to leave their mark. The ring around the brightest star near the top of the plate was produced by the reflection of the light which penetrated through the film to the back of the sensitive plate. Although we used a nonhalation or double coated plate, the light of that one star was sufficient in the long exposure of 9 hours to penetrate through the film.

What is the nebula? How far is it from us? Does it move? Does it change in form? These are questions which the reader would naturally like to have answered and no one would more gladly answer them definitely than the writer, if he could.

The visible spectrum of the Orion nebula consists of four bright lines, one in the violet which coincides with one of the four prominent hydrogen lines in the solar spectrum, and three in the portion of the spectrum where the green and blue colors meet. One of these latter is in the place of a hydrogen line, while the others do not coincide exactly with the lines of any known substance, although they are very close to those of magnesium. Mr. W. W. Campbell has recently, with the powerful spectroscope of the great Lick telescope, been able to see and to photograph several other bright lines and also a faint continuous background in the spectrum of this nebula. So far as we are able to draw any conclusion from this evidence, it would seem that the nebula is principally gaseous, a mixture of hydrogen and other gases unknown as yet, in a glowing state. The faint continuous spectrum would seem to imply that there is also some solid matter there. It is not safe, however, to infer that, under the unknown conditions which exist in the depths of space, the different substances will give the same spectra that they do in our laboratories.

As to the distance of the nebula nothing is known except that it is not measurably nearer or more distant than the stars. No measures have shown as yet any motion of the nebula with reference to the stars, and the latter seem to be stationary and immeasurably distant from us.

We can see from this that the dimensions of the nebula must be enormous, beyond our powers of conception, and that it is not strange that the changes, which must be going on, cannot be detected from year to year to year.

There is food for the imagination here and room for question to satisfy the most speculative minds. To what end is this vast expanse of fiery mist? What mighty and mysterious forces are at play? Are those gigantic outer wreaths moving outward or are they falling in toward the center? Is this the beginning of worlds or is it the end?

Directions in the Sky.—Young observers are sometimes troubled about directions in the sky. In the celestial sphere the points of compass have, of necessity, a meaning which may seem different from that which we attribute to them on the Earth. *North* always means toward the north pole; *south*, from it; *west*, in the direction of diurnal motion; *east*, in the opposite direction.

SHOOTING STARS.

How to Observe Them and What They Teach Us.

W. F. DENNING.

IX. FIREBALLS.

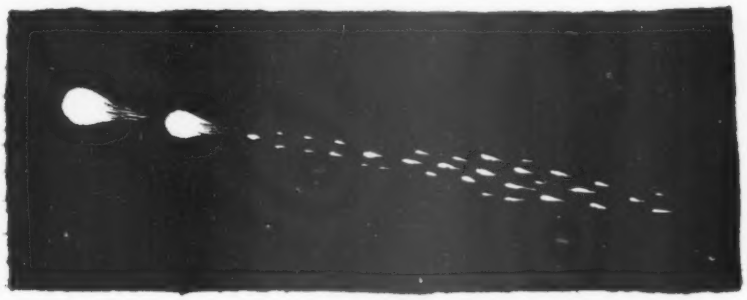
There is no doubt that Fireballs constitute an extremely attractive and striking class of meteoric phenomena. It is a pity that the times of their individual apparitions cannot be definitely predicted, for a remarkable degree of interest would then centre round them and the public would witness their outbursts with intense pleasure. Unfortunately, however, these brilliant objects come suddenly and unannounced, for the conditions under which they appear do not permit their times of appearance to be exactly foretold. In a general way it is quite possible to indicate a night (as for example August 10) when large meteors will certainly come into view, but the precise minute or position of appearance of the individual objects cannot be predicted.

Fireballs exhibit great variety in their visible features. Some move slowly, others are rapid; some pass silently athwart the sky, others produce violent detonations; some traverse their courses in the form of a pear-shaped ball of fire leaving no luminous track behind, others either throw off trains of sparks or generate the enduring phosphorescent streaks so characteristic of meteors which move swiftly. In color, too, and in visible length of path and direction of motion, great differences are met with, in fact it may be safely said that no two fireballs are precisely similar in all their observed features. Sometimes they are brighter than the Moon and abruptly light up the sky and landscape in a manner which cannot fail to startle the beholder. Nearly every one sees, at one time or another, a brilliant example of these phenomena and the effect is generally so sensational as to leave an indelible impression on the memory.

It is highly probable that fireballs are practically identical with ordinary shooting stars, the distinction being only one of size. Fireballs represent the largest class of meteors and probably have a community of origin with the tiniest shooting stars seen in powerful telescopes. Showers like the Perseids of August display the most brilliant fireballs as well as the faintest shooting stars, and they appear to be indiscriminately mixed together though there is certainly a great preponderance of the latter class. That they all belong to the same parent stream is manifest from their having a common radiant point.

The average height at which fireballs become extinct is about

30 miles, but in some instances it is considerably less than this, and not infrequently below 15 miles. Many instances might be adduced to show that the elevation at disappearance is sometimes as low as 5 or 10 miles, but the material of these bodies is generally exhausted before it is enabled to penetrate so deeply as this into our atmosphere. One of the largest fireballs of recent years appeared over England on Jan. 25, 1894 and burst, with a report like thunder, at a height of 16 miles. Just before its disappearance it exhibited a double nucleus and created a brilliant effect which can scarcely be described.



FIREBALLS OF JANUARY 25, 1894.

It is most unsatisfactory to reflect that though fireballs form events which, if properly utilized, are capable of greatly extending our knowledge of meteoric astronomy, they are seldom observed with sufficient accuracy to enable their real paths to be exactly determined. Every year there are scores of fireballs recorded, but it is only in rare cases that an investigation affords a good result. The observers of these apparitions are generally of a very miscellaneous character and their descriptions are often contradictory and untrustworthy. A definite and reliable path can seldom be extracted from such records. Two observations alone, if made by experienced eyes, are of far greater value than a mass of observations of an imperfect and erroneous nature. No doubt the sudden and unexpected way in which these bodies appear tends to confuse the ordinary spectator, and he retains a very hazy impression as to their paths and durations of visibility. With regular observers the case is different, and valuable details are sometimes to be gleaned from a discussion of their materials.

Fireballs are sometimes so astonishingly brilliant as to be visible at noonday in the presence of bright sunshine. A daylight meteor of this character was visible from many parts of England

on Febuary 8, 1894. It appeared about 30 minutes after noon and fell from a height of 80 to 20 miles.

There are certain dates in the year when large meteors are particularly numerous and it is desirable to ascertain whether this undue frequency is not in certain cases attributable to active radiants which have hitherto escaped prominent notice. Some years ago I compared many hundreds of observations of fireballs, and the following dates were those of greatest frequency.

January 2, 21, 31; Febuary 3, 7, 10; March 1, 2, 4; April 11-12, 19-20; May 2, 4, 15, 31; June 6-7, 22, 29-30; July 11, 20-21, 25-30; August 3, 5, 7-13, 15, 19-22; September 1-2, 6-7, 11-13, 25; October 13, 15, 17-18, 22, 24, 29; November 1-2, 4, 6-9, 11-15, 19, 27; December 8-9, 11-12, 21.

It will be seen that some of the dates correspond with the well-known showers such as Lyrids, Perseids, Orionids, Leonids, Gemenids, etc.

The following table contains the heights, etc, of some of the largest fireballs of late years, but the list is necessarily very incomplete:—

Date.	Height at Beginning	Height at Ending.	Length of Path.	Velocity; miles.	Radiant Point.	Authority.
	miles	miles	miles	per sec.	α δ ° °	
1863, Dec. 27	80	25	80	20	81 + 22	A. S. H.
1864, Aug. 8	106	82	29	29	320 — 15	A. S. H.
Dec. 8	90	30	75	58	95 + 30	A. S. H.
1865, April 29	52	37	75	20	73 + 47	A. S. H.
Sept. 24	67	38	91	23	2 + 2	A. S. H.
26	107	76	260	57	69 + 25	A. S. H.
1868, Sept. 5	250	85	1200	28	14 — 2	G. Von Niessl.
1869, Nov. 6	90	27	170	35	62 + 37	A. S. H.
1871, Aug. 31	44	40	42	7	β Herculis	A. S. H.
1872, July 22	77	37	88	...	246 — 11	I. H. Waller.
1873, June 17	101	20½	285	18½	247 — 19	I. G. Galle.
1874, April 10	45	18½	52	14	19 + 57	G. Von Niessl.
Aug. 10	66	33	85	19	313 — 14	A. S. H.
1875, Sept. 3	75	40	35	27	311 + 52	G. L. T.
7	82	22	50	18	347 + 15	G. L. T.
14	52	13	104	13	348 ± 0	G. L. T.
1876, April 9	100	20	200	25½	17 + 57	G. Von Niessl.
July 26	62	27	107	26	258 — 24	A. S. H.
Aug. 15	69	34	130	19	310 — 10	A. S. H.
Sept. 24	58	16	45	15	285 + 35	A. S. H.
1877, Jan. 19	75	45	230	35	135 + 27	A. S. H.
Mar. 17	60	29	58	19	145 — 4	G. L. T.
April 6	80	20	165	31	275 + 50	A. S. H.
June 14	157	27	170	42½	212 + 12	M. Greecy.
Nov. 23	95	14	135	17½	62 + 21	G. L. T.
1878, Mar. 25	50	22	130	33	332 — 20	A. S. H.
April 2	60	15	50	14	177 + 49	G. L. T.
May 12	78	17	155	15½	214 — 7	A. S. H.
June 7	65	37	160	19	247 — 25	A. S. H.
July 29	82	20	70	23	290 + 42	A. S. H.
1879, Jan. 12	40	9	124	18	133 + 19	G Von Niessl.
28	100	26	124	slow	142 + 14	D. Kirkwood.
Feb. 21	62	6	85	21	140 + 51	A. S. H.
1886, Aug. 4	90	11	168	21	161 + 59	W. F. D.
Nov. 17	96	21	123	17½	34 + 19	W. F. D.
1887, May 8	70	14	110	18	191 — 5	W. F. D.
1888, Aug. 13	78	47	46	swift	43 + 56	W. F. D.
1889, May 29	58	23	76	8½	216 — 7	D. Booth
1891, Sept. 30	54	24	56	13	14 + 7	W. F. D.
1893, April 15	99	40	158	slow	15 + 59	W. F. D.
1894, Jan. 25	89	16	160	18	331 + 55	W. F. D.

The abbreviations in the last column are as follows:— A. S. H., Professor A. S. Herschel, G. L. T., Lieut.-Col. Tupman, W. F. D., W. F. Denning.

Some of the results quoted are not very exact, but they are probably as reliable as the circumstances allow. If bodies of this character were only observed with completeness and by persons acquainted with the essential points to be recorded, then a few years would add enormously to our stock of materials. The fireballs included in the list are but a few amongst the many thousands which have appeared during the last quarter of a century. We have selected only a few drops, as it were, from a continuous and widely dispersed shower; but from the few we may perhaps fairly judge of the general character of them all.

At a future time when the science has grown more popular and the general public has become better acquainted with its requirements the exact observation of fireballs will doubtless be more often accomplished than at present. No objects come more often under the public eye or excite more interest than these, and they deservedly occupy a high position whether we regard them as popular spectacles merely or as objects capable of enhancing our knowledge when critically studied.

E. E. BARNARD'S WORK AT LICK OBSERVATORY.*

S. W. BURNHAM.

During the observations of comets and stellar systems at Mt. Hamilton, Barnard found many new nebulæ some of them being of more than ordinary interest. One of these is somewhat noteworthy from its situation and history. A good many years ago, in 1859, the Italian astronomer Tempel found that the star Merope, one of the bright stars of the Pleiades, was surrounded by a large diffused nebulosity. This was so difficult to see, principally on account of its large extent as compared with the largest field of view which could be used with ordinary instruments, that many observers doubted its reality. It was subsequently shown that the failures to see it were due to not having a sufficiently large field to give the necessary contrast of nebula and sky; and its existence was verified later by photographs made at Paris, Cambridge and elsewhere, which not only showed a greater extent

* Continued from April number. This is the third of a series of articles, portions of which have already appeared in *Harper's Magazine*, August, 1893.

of this nebula, but also that there was nebulous matter enveloping all the other bright stars of the Pleiades. While looking at this region with the great telescope at Mt. Hamilton, Barnard detected a small, round and well defined nebula, so close to Merope that it was involved in the light of the star. It was very difficult to see for this reason, and on account of its faintness, and it would be overlooked with any instrument by all but the most expert observers in this line of work. It is unique with respect to its proximity to a bright star. The relative positions of the two objects were carefully measured so that any change hereafter can be detected. In the same general locality he also discovered an interesting nebula of the planetary class, comparatively few of which are known.

His long experience in all departments of the photographic art were turned to practical account at the Lick Observatory in the direction of celestial photography. He was the first to photograph the Milky Way and show the wonderful forms of its structure. This work attracted wide-spread attention, and down to the present time it has not been equaled by anyone. Many other specially interesting regions of the sky, as, for example, the Great Nebula in Andromeda, the Pleiades, and other well-known central points of interest, have been photographed by him. This work, it should be remarked, was not done with a large equatorial, or with a telescope of any kind, but with a large portrait lens, fastened to an equatorial telescope with driving-clock in order to follow the objects during the exposure. The driving-clock of the instrument is used to keep the stars at the same general point on the plate, but it is necessary to watch the finder constantly during the whole time to prevent any displacement of the images from accidental or other causes, and this was a very laborious work, since some of the exposures were continued for over five hours.

Among other specially interesting subjects photographed with the same instrument was the comet of March, 1892. This was discovered by Dr. Swift of Rochester on March 6th. It rapidly increased in brightness and became somewhat prominent in the morning sky in the early part of April. It was photographed several times with exposures varying from one to two hours, and remarkable results were obtained, showing the division of the tail into several distinct streams of cometic matter, invisible except in the photographic plate, which took place in the structure and appearance of the tail which at this time was more than twenty degrees in length. These are the most successful photographs

ever taken of a comet. This was the largest comet visible in the northern hemisphere since the great comet of 1882. The motion of the object during the exposure is shown by the elongated discs of the stars.

The total eclipse of the Sun of January 1, 1889, which was visible in Northern California, was photographed very successfully with a non-photographic telescope of three inches aperture, and the pictures obtained of the corona have not been surpassed at any time. Comparatively few eclipse pictures in the last fifteen years have been very successful from either a technical or scientific point of view.

The photograph of the Great Nebula in Andromeda and the region surrounding it was from an exposure of more than four hours. This shows the complete structure of the nebula, and the myriads of stars surrounding it. The negative contains not less than 64,000 stars, and of this number less than half a dozen are visible to the naked eye.

The visual observations at Mt. Hamilton during the four years he has been connected with it, embrace a wide range of subjects. Asteroids, nebulæ, double stars, planets, the Moon, Sun-spots, meteors, occultations, eclipses, etc., have all received a good deal of time and study. In many instances these observations will have a greater value a century hence than they have to-day.

In November, 1889, the rare phenomena occurred of an eclipse of Iapetus, the eighth satellite of Saturn, in the shadows of the Ring System of the planet, and it was carefully observed by Barnard for the purpose of determining the nature and density of the so-called dark or crape ring of Saturn. The observation established the remarkable fact, which had been long suspected but not entirely proved, that this mysterious ring discovered by Bond in 1850 is really transparent, and therefore possibly composed of minute portions of matter surrounding the planet like a dense swarm of satellites. It is not probable that these particles will ever be seen separately by any telescope. The effect in the most powerful instrument is simply that of a surface with the power to reflect a feeble amount of light. This very rare phenomenon of the eclipse of Iapetus was the first ever seen, and was witnessed by no other observer in the world.

In 1888 when the 36-inch telescope was first mounted, Mr. Alvan G. Clark discovered an exceedingly faint star within Trapezium of Orion. A good many mythical stars had been placed here by people with little experience in this kind of work; but it was long ago shown that they were purely imaginary stars, and

that instruments like the 18½-inch at Chicago and the 26-inch at Washington, both of them more powerful than any used in the alleged discoveries, failed to show under the most favorable conditions the least trace of any star within the famous Trapezium. The Lick telescope revealed this star, and the writer, after having repeatedly measured its position with reference to the bright stars around it, has no hestitation in saying that no other telescope in the world can show it. In looking at this, Barnard added a still fainter star, within the Trapezium, and also detected just outside of this area, a double star so excessively faint and difficult that it could be measured on only one night during the period covered by the other measures referred to. No other double star like this is known in the heavens.

In February, 1892, a new star suddenly appeared in the constellation of Auriga, and attracted the attention of astronomers everywhere. It was readily visible to the naked eye, but soon faded, and by the last of April it could be seen only in the most powerful telescope. Its position in the evening sky prevented astronomers from longer following it, but as its decrease in light had been uniform, it seemed almost certain that it would continue down the scale of magnitudes, and pass beyond the limit of human vision forever. As soon as this region could be again examined in the early morning hours, it was found by a number of observers to have increased in magnitude, so that it was within reach of an instrument of not more than three inches aperture. When Barnard turned the great telescope upon this object, he saw at once that the previous star had become the nucleus of a small bright nebula. This wonderful change, the transformation of a star into a nebula in less than five months, and which defies all theories offered in explanation of the original outburst, has been confirmed by spectroscopic observations at Mt. Hamilton and elsewhere. The history of astronomy presents no authenticated instance of a similar transformation, where the resulting nebula has been actually visible in the telescope.

If has been already stated that from the beginning of his work with the telescope, Barnard has given special attention to the planet Jupiter. In 1890, the planet was observed by him on forty-nine nights with the 12-inch equatorial and careful measures made of all the markings on the planet. In September of that year he observed the singular phenomenon of a double transit of the first satellite across the disc of Jupiter. Projected on the face of the planet it appeared distinctly double resembling a

close double star, the components being slightly unequal. This remarkable appearance has not yet been accounted for. It was probably due to a bright belt on the satellite, similar to some of those on Jupiter. The observations would imply that the satellite in its revolution about Jupiter, rotates on an axis nearly perpendicular to its orbit, as in the case of our own moon. The observations might also imply that the first Moon of Jupiter is really double, though this explanation is hardly probable.

In July, 1892, he commenced to use regularly the large telescope on one night each week, and naturally began systematic observations of the great planet. It was but a short time before the superiority of the largest telescope in the world for this work was made manifest. In due course of mail the writer received at Chicago a letter from Professor Barnard written on Saturday morning, September 10, stating that on the previous evening (Friday) at about midnight he had observed an extremely faint speck of light very close to Jupiter; that it seemed to be moving with the planet; and that he strongly suspected it was a new satellite. He said that it was so difficult with the large telescope, that he was unable to see it except by shutting out the light of the planet. The suspected star was found by the observations of the following night to be a new satellite, and on Monday morning the whole astronomical world was electrified by the announcement that Jupiter, observed more than any other planet for the past three hundred years, had a fifth moon, revolving about it in less than twelve hours, at a distance from the surface of the planet of about 70,000 miles. Since that time, Barnard has measured its position at every available opportunity to supply the data for accurately computing its orbit. He finds that its periodic time is $11^h\ 57^m\ 23^s.1$ and that its distance from the center of Jupiter is 112,500 miles. From careful observation it seems to shine with the light of a thirteenth magnitude star and is perhaps less than one hundred miles in diameter, which makes it a very minute world indeed as compared with the older moons of Jupiter. The four satellites discovered by Galileo in 1610 vary from 2100 to 3500 miles in diameter, and revolve around the planet in times varying from one and three-fourths days to nearly seventeen days. The distances of these bodies from Jupiter are from 260,000 to 1,162,000 miles. How much more interesting the new satellite is, will be obvious from these comparisons. It will always be beyond the reach of all but the largest telescopes, and can then be seen only when near its maximum distance from the primary. At the present time it has been seen by Professor

Hough with the 18½-inch telescope of the Dearborn observatory; by Professor Young and Mr. Reed with the 23-inch at Princeton; by Professor Stone with the 26-inch at the University of Virginia; and at Washington with the 26-inch refractor of the Naval Observatory.

It is hardly necessary to say that this is one of the most important astronomical discoveries of modern times. The most powerful telescopes, and the most skilled observers have been given to the study of this planet, and while the investigation of the surface has revealed new details, no one seems to have hoped to add any new moons to the four discovered by Galileo when he first turned his rude instrument on the planet nearly three hundred years ago.

Still more recently this indefatigable observer made another discovery which is characteristic of the originality and thoroughness of his methods. On the night of October 12, he discovered a new comet by photography. A photograph of the Milky Way in the constellation of the Eagle was being made, and an exposure of four hours and a half was given, and when the plate came to be examined after development, the expert photographer recognized the strange visitor by its motion on the plate during the time of exposure. On the following evening it was verified and its position determined by the micrometer in the usual manner. This is the first comet discovered by photography, and is consequently historical. Singularly enough the comet has been found to be of more than ordinary importance as it has been shown to be periodic, its revolutions round the sun being accomplished in about six years. This has suggested a new field for the discovery of comets, and it is not unlikely that hereafter many such may be found by this method.

The services of Professor Barnard in the line of original astronomical research have been recognized by scientific societies. He has been a Fellow of the Royal Astronomical Society of London, since 1887. He is also a member of the British Astronomical Association, the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and many other learned and scientific Societies. In 1889, the Honorary Degree of M. A. was conferred upon him by the University of the Pacific in recognition of his important astronomical work.

It has been the privilege of the writer to work for four years at the Lick Observatory by the side of the subject of this sketch; and he has learned by a very intimate acquaintance and friendship to have the most profound respect for the personal qualities

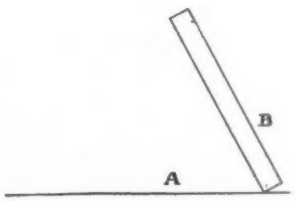
and scientific acquirements of Professor Barnard. This article does but scant justice to either. The simple-minded nature of the man, his unselfishness, his modesty, and genial nature are most thoroughly understood and appreciated by those who know him best.

[Since the foregoing was written, Professor Barnard's Astronomical discoveries have received the highest recognition of the French Academy of Sciences by the award to him in January of the Lalande gold medal.]

TESTING OPTICAL GLASS FOR THE QUALITY OF ITS ANNEALING.

JOHN. A. BRASHEAR.

Annealing is a term used in a technical sense in reference to almost any material worked in the arts which has a crystalline structure, and which, in the process of manufacture is brought up to high temperature and then allowed to cool slowly.



As stated in one of our former articles, the perfect annealing of large discs of optical glass is a most difficult matter, and the greatest care must be taken, that, at the critical point, the lowering of the temperature shall be graduated with the greatest delicacy to produce the best results.

Annealing means in reality that the molecules shall have plenty of time given them to fall into a natural or normal condition. Just as this condition is conserved will the glass be the better for optical purposes. With small discs and plates the process is not nearly so difficult as with the larger discs.

It is fortunate that the condition of a piece of glass, as far as its annealing is concerned, is easily determined before a lens is made from it. Were it not so and the optician had to work the discs into a lens before he could know for a certainty that the glass was good or bad, many precious hours lost and final disappointment would be the result.

In the figure before us (inadvertently placed on page 293 No. 7, of this Journal,) we have the method illustrated.

A may be a plate of ordinary window glass or plate glass varnished with black varnish on the under surface, or it may be a piece of black muslin or oil cloth, one side of which has some lustre. This should be laid on a table or on the floor so that a strong light from the sky or light clouds shall fall upon it, preferably discarding any direct reflection from the Sun. This black reflecting surface is the source of our polarized light. The plate of optical glass, already polished, is set up on edge at an angle approximately as given, no exactness being required, although the nearer the polarizing angle for glass 56° + the more marked will the effect be.

A small nicol prism C, — one a quarter of an inch on the face will answer, — is now placed in front of the eye D and directed toward the glass and source of light. On rotating the nicols prism, a black cross similar to a maltese cross will appear and disappear, provided the glass is fairly well annealed. If this black cross is symmetrical in shape with relation to the shape of the disc and is faintly marked, we may rest assured we have a fairly well annealed disc, and the less marked the cross the more perfect is the annealing. So feeble is the black cross in the 23″ discs, noted in a former article, that their remains not a shadow of a doubt that the annealing in this case leaves little to be desired.

If the cross is strongly marked, but symmetrical and has no color associated with it, it still promises well, and generally a good objective can be made from it.

It sometimes happens that the cross is distorted; at other times there is no semblance to a cross and the figure is broken up into various shapes. In this case the disc or plate is poorly annealed. It may also show *color* which is fatal to good work, and the glass had better be discarded. It is not our intention to give the *rationale* of these phenomena, as they may be found in any text-book on Optics, but suffice it to say that the one satisfactory answer is this; if the molecules of the glass are in a state of strain, or in an abnormal condition, light cannot pass through

it naturally or normally, and hence it is unfit for that class of objectives demanded in astronomical or physical research.

A more delicate method of testing for strains is to use a concave silvered mirror, as described in the method of testing for striæ in the March number of this journal, page 292. The plate or disc to be tested is set up in front of the mirror exactly as there described.

We now need an additional piece of apparatus in the way of a thin piece of selenite. This is mounted in a piece of cork or cemented on a plate with an opening in the plate say five millimetres diameter. This is now placed in front of an opening of the screen covering the lamp, and is placed near the center of curvature of the mirror so that the polarized beam may be returned through the glass to be tested. The lamp is placed to one side so that the returning beam may be observed by the aid of our nicols prism.

Examining this beam which has passed twice through our plate or disc of glass, we can detect very minute strains, indeed few pieces of glass will stand this delicate test without showing some molecular tension. However the first method is sufficient for all practical purposes after one learns how to "diagnose" the appearances brought out by the tests given.

CONSTELLATION STUDY.

WINSLOW UPTON.

VIII.

In this article—the last of the series—we are to consider the constellations of the fourth division of the sky, which is between 18 and 24 hours right ascension. The circumpolar groups of this division, Draco and Cepheus, were discussed in the IVth paper. The zodiacal constellations are Sagittarius, Capricornus and Aquarius.

Sagittarius. There are two prominent characteristics of this group, one independent of the figure and the other marking the position of the Archer's bow. The former is the "Milk Dipper," so called from its position near the Milky Way, and consists of four stars forming the bowl and a fifth for the handle. The dipper is inverted, when the constellation is near the meridian in northern latitudes. The star at the end of the handle, λ, is in the Milky Way and the others, φ, σ, ζ and τ are east of it, 3° to 5°

apart. The group may be found by drawing a line eastward from Antares 30°, or where this line crosses the Milky Way. The lines forming this dipper are not drawn on Poole's chart. The second characteristic is a doubly curved line of stars, running north and south in the Milky Way. The stars are μ, λ, δ, ε and η. 4° west of the middle star, δ, is γ, which marks the head of the arrow projecting beyond the bow. The bowl of the dipper is in the Archer's shoulder, and the only other conspicuous star of the group is π, the brightest of a little group marking the head, and situated about 8° north of the bowl. μ is near the southern solstitial point.

Capricornus. The characteristic figure of this group is a large triangle of curved sides, composed of stars which are rather faint but easily traced, and resembling a spherical triangle as it might be projected on a plane. The curvature of the northern side is towards the south or inwards, while that of the others is towards the southwest and southeast respectively, or outwards. The group lies in the relatively vacant region northeast of Sagittarius. The lines are drawn on the chart, but are partly beyond the limits of the maps in this issue of POPULAR ASTRONOMY. The northwestern, northeastern and southern vertices are marked by the stars α, δ and ω respectively, the last named the faintest of the three. In the classic figure the head of the goat is at the northwestern vertex of the triangle.

Aquarius. This group occupies a large area situated both north and east of Capricornus. Its most interesting feature is a little triangle of faint stars with a much brighter one, ζ, in the centre. This lies about half way between the eastern vertex of the triangle of Capricornus, and the southern side of the Square of Pegasus in a northeasterly direction. It forms the Water Pot; and from the southeastern side of the triangle may be traced a curved band of faint stars convex towards the east and terminating in the brilliant star Fomalhaut of the constellation Piscis Australis. The two brightest stars of Aquarius lie west of the Water Pot; α is 6° east of ζ, and β is 8° southwest of α. The stars α and β mark the shoulders of the Water Carrier. The star θ, 7° south of the line $\zeta\alpha$ is in the body, and two stars, τ and δ, a little east of the straight line joining ζ with Fomalhaut, mark the left leg of the figure. One arm is extended toward the west, north of Capricornus, in which several stars may be seen. The chart gives a different plan for tracing the stars of this constellation.

The only constellation readily visible in the middle northern latitudes south of these zodiacal groups is Piscis Australis.

Piscis Australis. This is also called Piscis Austrinus and Piscis Notius. Its chief mark is the first magnitude star Fomalhaut, which is in the mouth of the fish. The water from the Water Pot of Aquarius is represented as flowing into the fish's mouth.

The constellations north of the zodiac will be described beginning with those which adjoin the circumpolar groups.

Lyra. The first magnitude star Vega makes it easy to find this constellation, which lies east of Hercules and south of Draco. Vega with two fourth magnitude stars 2° from it forms a small nearly equilateral triangle; the northernmost, ε, is a famous quadruple star. Ordinarily one star is seen, but a specially keen eye on a favorable occasion will be able to see that it is really a double star, while the telescope shows that each of the components is double also. Two third magnitude stars, β and γ, about 6° southeast of Vega, and forming with it an elongated triangle, complete the main features of the group. Between β and γ is the ring nebula of Lyra,—a beautiful object in the telescope. A number of fainter stars east of those described can be readily traced.

Cygnus. The characteristic figure of this group is the Northern Cross, which lies east of Lyra. It is formed of five stars, four marking the extremities of the bars of the cross, which is of the Roman form, and one their intersection. The star at their intersection, γ, is a little east of the actual crossing point of the two lines $\alpha\beta$ and $\delta\varepsilon$, but the figure is, (for stellar figures), quite exact. A large number of other stars are in the area called by the name, but only one compares with these in brightness, ζ, which is about 7° southeast of ε, the line $\varepsilon\zeta$ being inclined somewhat to the short arm of the cross. The long bar of the cross forms the body and neck of the Swan, and the short arm marks the position of the wings. The latter can be more fully traced by continuing the cross arm by the stars ζ, μ, on the south and θ, ι, κ, on the north, as shown on the chart, and a group of small stars northeast of this broken line and including the star α at the top of the cross, encloses the area occupied by the extended wings. α is important because of a brightness which places it almost exactly on the arbitrary dividing line between stars of the first and those of the second magnitude.

Lacerta. This is the name given to a small area between Cygnus and Andromeda. It contains no conspicuous stars, two of the fourth magnitude marked 1 and 7 on the chart being the brightest.

Aquila and *Antinous.* This double name is given to the area east of the southern part of Hercules and of Ophiuchus. The name Aquila has come down from Ptolemy, and that of Antinous was formally assigned to the southern part of the area by Tycho Brahe, though it seems to have been used also by Ptolemy in designating this region but not as a separate constellation. The eagle is represented as resting upon the youth Antinous who was a favorite of the Roman emperor Adrian. The characteristic figure is a line of three stars about 2° apart, the middle of which is Altair or α Aquilæ, a brilliant first magnitude star. In the northwestern part of the area, where the tail of the eagle is drawn, is a third magnitude star, ζ. In the southern part of the area occupied by Antinous are three third magnitude stars, δ, θ and λ (Aquilæ), which form a right-angled triangle. The line of the three stars first named, γ, α, β, leads to θ about 8° beyond β, and the line $\delta\lambda$ lies west of θ. A different plan for tracing this group is given on the chart.

Sagitta. The line from Altair to β Cygni, the star marking the foot of the Northern Cross, intersects a line of three fourth magnitude stars about 3° apart, the western of which has a companion of equal brightness south of it. These four stars mark the Arrow.

Delphinus. East of Aquila is an easily recognized group, consisting of four stars forming a small quadrilateral and a fifth star south of the four. This is the characteristic figure of the Dolphin.

Vulpecula. This name is given to the area immediately north of Sagitta and Delphinus and south of Cygnus. There is no conspicuous star in the area, the brighest, numbered 1 on the chart, being a fourth magnitude star, and lying near the neck of the Goose which the Fox holds in his mouth.

Pegasus. The characteristic feature of this large area is the Square, composed of three third magnitude and one second magnitude stars, forming a quadrilateral whose sides are about 18° in length. It is in the eastern part of the area, and the eastern side nearly marks the equinoctial colure. The northeastern star is on the boundary between Andromeda and Pegasus and is usually known as α Andromedæ, though Bayer called it also δ Pegasi. Adjoining the northwestern star β is a third magnitude star η, which marks the position of one leg of the Winged Horse. The neck and head are traced by the three stars ζ, θ and ε, the two former in line with the southwestern star of the Square, the

line running southwest, and ε bearing northwest from θ and distant about 8°.

Equuleus. This name is retained from Ptolemy for the small area between ε Pegasi and Delphinus. A few faint stars may be noted, marking the head of the Little Horse, which is the only part of the animal represented.

Scutum. This name refers to the shield of Sobieski, and the word Sobieski, Sobieskii, Sobiesii or Sobiescianum is sometimes added. The last named was that used by Hevelius who is responsible for the constellation. It occupies the small area north of Sagittarius, between Aquila and Serpens. West of λ Aquilæ may be seen six or seven faint stars somewhat scattered, which are in the area thus named.

The celestial equator passes through the constellations Aquila and Aquarius. It is about 8° south of Altair and about 1° north of α Aquarii. The ecliptic passes through the constellations in which the Sun moves in the winter months. At the winter solstice, the Sun is near μ Sagittarii, and in January he journeys through the northern part of that constellation. In February he passes through Capricornus, crossing the southwestern and northern sides of the triangle marking that area. In the latter part of the same months he is about 8° south of the Water Pot of Aquarius.

The constellations of this division are best studied in the evenings of the summer months. The following are the positions of the leadlng stars.

APPROXIMATE POSITIONS OF THE LEADING STARS IN THE CONSTELLATIONS BETWEEN XVIII^h AND XXIV^h RIGHT ASCENSION, OMITTING CIRCUMPOLAR CONSTELLATIONS.

Name.	Magnitude.	Right Ascension.	Declination.
		h m	° ′
LYRA.			
α	0.2	18 34	+ 38 41
β	3.6	18 46	33 14
γ	3.2	18 55	32 34
CYGNUS.			
β	3.1	19 27	+ 27 45
δ	3.0	19 42	44 53
γ	2.3	20 19	39 56
α	1.5	20 38	44 55
ε	2.7	20 42	33 35
ζ	3.5	21 9	29 49
LACERTA.			
No bright stars.			

Aquila.

Name.	Magnitude.	Right Ascension. h m	Declination. ° ′
ζ	3.1	19 1	+ 13 43
λ	3.6	19 1	− 5 2
δ	3.5	19 20	+ 2 55
γ	2.8	19 42	+ 10 22
α	1.0	19 46	+ 8 36
β	4.0	19 50	+ 6 9
θ	3.4	20 6	− 1 8

Sagitta.

No bright stars.

Delphinus.

ε	4.1	20 28	+ 10 58
β	3.7	20 33	14 15
α	4.0	20 35	15 33
δ	4.6	20 39	14 43
γ	4.0	20 42	15 46

Vulpecula.

No bright stars.

Pegasus.

γ	3.0	0 8	+ 14 38
ε	2.4	21 39	9 25
θ	3.8	22 5	5 42
ζ	3.6	22 36	10 18
η	3.1	22 38	29 42
β	2.6	22 59	27 32
α	2.6	23 0	14 40

Equuleus.

No bright stars.

Scutum.

No bright stars.

Sagittarius.

γ	3.0	17 59	− 30 25
μ	4.1	18 8	− 21 5
η	3.0	18 11	− 36 48
δ	2.8	18 14	− 29 53
ε	2.1	18 17	− 34 26
λ	3.1	18 22	− 25 28
φ	3.3	18 39	− 27 6
σ	2.3	18 49	− 26 26
ζ	2.9	18 56	− 30 1
τ	3.5	19 1	− 27 49
π	3.1	19 4	− 21 11

Capricornus.

α	3.8	20 12	− 12 52
β	3.4	20 15	− 15 7
ψ	4.3	20 40	− 25 38
ω	4.4	20 46	− 27 18
θ	4.3	21 0	− 17 38
ζ	3.8	21 21	− 22 51
γ	3.8	21 34	− 17 7
δ	3.0	21 42	− 16 35

AQUARIUS.

Name.	Magnitude.	Right Ascension. h m	Declination. ° ′
β	3.1	21 26	− 6 1
α	3.2	22 1	− 0 48
γ	4.3	22 12	− 8 17
ζ	3.8	22 24	− 0 32
δ	3.4	22 49	− 16 22

PISCIS AUSTRALIS.

α	1.3	22 52	− 30 9

In these articles, only casual mention has been made of constellations which cannot be well studied by observers in the United States or in similar northern latitudes. It may not be out of place however to allude more fully to the constellations of the southern hemisphere. As the early observers were in the northern hemisphere, only the constellations visible to them have the peculiar authority which dim antiquity gives. Ptolemy gives two constellations only, Ara and Corona Australis, in the southern sky. These are inaccessible to most northern observers. Bayer about 1600 A. D. added twelve, not from personal inspection but probably from records of navigators. In the 17th and 18th centuries many others were added, especially by LaCaille as the result of his own observations at the Cape of Good Hope. While the attempt was made to follow the ancient plan, the new constellations were much smaller than the old and there was no general agreement as to their adoption. Several eminent astronomers of this century have attempted to remove the discrepancies and perfect a system which shall meet with general favor. It should be remembered that while the need of such revision is quite apparent to the student of the skies, the use of the constellations is of such minor importance in the science of astronomy that relatively little interest is taken in the subject, which is so largely of antiquarian value merely. The slow process of "gradual consent" however tends to the acceptance of the groupings of Ptolemy, Bayer and La Caille with few alterations, and to the rejection of nearly all of those suggested by other observers. Even thus, the system is not satisfactory, but there are no difficulties in it which are not inherent in the whole subject of the constellations, formed as they are on the capricious plan of the ancients.

It is not intended to offer any detailed description of the southern constellations, but it may be well to close the subject by giving a simple list of those which are generally accepted. The fol-

lowing table therefore contains their names. The order is from 35° south declination towards the south pole and the groups are given in the four divisions adopted in these articles. The list may be regarded as an extension of the table given on page 59 of this volume of POPULAR ASTRONOMY.

CONSTELLATIONS SOUTH OF DECLINATION —35°.

I.	II.	III.	IV
Caela Sculptoris.	Antlia Pneumatica.	Norma.	Sculptor.
Fornax.	Piscis Volans.	Ara.	Grus.
Phœnix.	Chamæleon.	Circinus.	Microscopium.
Equus Pictoris.	(The larger part of	Crux.	Corona Australis.
Horologium.	this division is	Triangulum Australe.	Indus.
Dorado.	occupied by Argo Navis.)	Musca.	Telescopium.
Reticulum.		Apus.	Toucan.
Mons Mensæ.			Pavo.
Hydrus.			Octans.

Argelander adds Machina Electrica, Nubecula Major and Nubecula Minor to the first division of this list. Poole's hand-book omits these and also Caela Sculptoris, Norma, Microscopium and Telescopium, according to the decision of Baily in the British Association Catalogue. Gould in the Uranometria Argentina, adds Pyxis Nautica to the IId division. All of the atlases subdivide Argo into three or four parts named Carina, Puppis, Vela, and Malus. The last corresponds with Pyxis Nautica.

As stated in the first paper of this series, it is impossible to state the exact number of the constellations in the sky on account of the differences in the southern sky. Adopting the list as here given, the total number is 85, one of which, Argo, is in four subdivisions. The number given by various writers, based on the work of different astronomers would be upwards of a hundred.*

THE PLEIADES.

WM. W. PAYNE.

As a group of stars the Pleiades has attracted more attention, in ancient or in modern times, than any other cluster known to Astronomy. When above the horizon the group is easily seen by the naked eye because of its definite outline and its bright and beautiful light. Long ago the sacred writer said of it: "Canst thou bind the sweet influences of the Pleiades?" Whatever that

* See Chambers Astronomy, ed. 1890, III, chap. VII.

PLATE XXII.

THE PLEIADES NEBULA AND TRAIL OF ASTEROID
NO. 203 POMPEJA.

From a Photograph by H. C. Wilson at Goodsell Observatory
Jan. 30, 1894. Exposure 4 hours.

may mean, in fact or figure, it certainly can not be less than the mystic reveries of those ancient untutored races who saw in them the seven benificent sky-spirits of the Vedas and the Zendavesta, and the abode of Diety himself, became the center of the universe. The time of the Pleiades was the beginning of the year for some primitive peoples, for others, the midnight culmination of the group was the sign for great feasts and royal mercy and favor for every petitioner. Even now savage Australian tribes dance in honor of the "Seven Stars" because they are good to the black fellows.* They are called "the hoeing stars of South Africa and their last visible rising after sunset is, and has been, celebrated with rejoicing all over the southern hemisphere as betokening the waking-up to agricultural activity." The influence of the Pleiades has been wide-spread and unique in all time, and modern science has not yet set a limit to the wonders of their starry realm.

At the present time six stars of the group are easily seen by the naked eye. Their names are: Atlas, Alcyone, Merope, Maia, Taygeta and Electra. By referring to the accompanying plate these and others less bright may be readily identified. The two bright stars on the left hand side are Pleione and Atlas. Pleione is above Atlas and they are midway in the plate from top to bottom. Alcyone is in the middle of the plate with three little stars on the left and surrounded with a faint nebulous halo. The wonderful Merope is next and a little below. It looks somewhat like the nucleus of a telescopic comet with the tail pointing downward and to the right. The star and the nebula bear the same name and are wonderful objects. Notice the numerous parallel channels in that vast nebulous mass. Maia is next above forming nearly a right-angled triangle with Alcyone and Merope. It is surrounded by a nebulous halo. A little to the right and above is Taygeta. The sixth bright star, Electra, is on the right side of the plate about midway from top to bottom. It has a nebulous streak from it to the left. Stronger eyes will see five more stars in the group. Pleione is one, the two stars by the one name, Asterope, looking as one just above Maia make two usually harder to see by the unaided eye. The third is Celæno nearly midway between Taygeta and Electra, and the fourth and fifth, not especially named, are seen respectively at the bottom and the top of the plate. Alcyone is a third magnitude in brightness, Electra and Maia are about 3.8 magnitude, Maia is 4th, Merope and Taygeta

* Clute's System of the Stars, p. 221.

are not so bright as Maia by respectively a quarter and a half magnitude and Celæno is a 7th magnitude.

The word Pleiades is from the Geeek, meaning full or complete, so that it is not certain that the name limits the number of stars visible to the naked eye in ancient times, although the number seven is frequently applied to the group in such records. However it seems probable that seven stars could be as easily seen in the past as the six that are now commonly visible. Professor Pickering suggests the probable explanation from a study of its spectrum that Pleione is the missing Pleiad, as its variable character might account for its fall to 6.2 magnitude. The record of naked-eye observations on this group of stars is an instructive one. Mœstlin in the time of Kepler saw 14 and mapped 11 with surprising accuracy. This was before the time of the telescope. Miss Airy of England has marked the places of 12. Carrington and Denning have counted 14, and Carl von Littrow spoke o seeing 16, and that 11 were frequently perceived.

An opera glass helps the eye amazingly in the study of the group in regard to color and number. Nearly one hundred stars come out at once on the astonished gaze, 25 of which are of the 7th magnitude or brighter, with many others less bright, and yet distinct enough to count with certainty.

In a region about Alcyone covering an area of 135′ by 90′, M. Wolf, in 1876, catalogued at the Paris Observatory, 625 stars to the fourteenth magnitude. M.M. Henry's sensitive plates showed in a smaller space 1,421 in 1885, and by four hours exposure in 1887 the same space revealed the astonishing number of of 2,326, including stars undoubtedly as small as the sixteenth magnitude. The meaning of this statement may be more fully realized when we remember that the sharpest eye unaided can never see well, at one time, more than 2,000 or 3,000 stars. Before the time of telescopes the total number of stars that the ancient observers could see well enough for record was 1,100. The marvelous thing in the count on the Henry photograph is the fact that 2° 15′ by about 1° 30′ of the space occupied by the Pleiades' group contains stars enough to fill the whole sky, if the 2,326 were brought near enough to us and sown broad-cast in the sky as the lucid stars now appear.

The accompanying plate covers a little smaller area than the Henry photograph just referred to, and our reproduction from the original negative has occasioned the loss of many of the stars plainly shown in making positives or pictures of any kind from the original photograph.

Another useful line of work on the Pleiades group is the measurement of the distances and positions of all the principal stars from the central one, Alcyone. This has been very carefully done three or four times during the last fifty years, so as to obtain data for the study of the relative motions of these stars in order to learn something about the physical constitution of the group. Dr. Elkin of the Yale Observatory has also recently done some work of a similar kind by the aid of a fine heliometer, which is sometimes called a survey of the Pleiades by triangulation. His results are useful in getting the exact time of the occultation of stars in the group by the Moon as she moves rapidly through it, by knowing the exact place of each star so occulted.

The most surprising advance in our knowledge of the Pleiades is the discovery of vast nebulous masses scattered over a large portion of the area of this cluster. If we except some earlier accounts that seem doubtful, the first observer that called attention to nebulous matter in the Pleiades was Tempel, an Italian astronomer, in the year 1859. His drawing is found in No 5 of the publications of the Milan Observatory, and represents a hazy, comet-like mass surrounding Merope and extending southward from it to the distance of half a degee. In 1882 Mr. E. E. Barnard then of Nashville, Tennessee, observed this nebula with a small telescope and made a drawing of it which was published in No. 3 of the *Sidereal Messenger* of that year. Quite generally, however, astronomers were in doubt in regard to the existence of this nebula, some claiming that search for it with first class instruments had been fruitless, while others maintained that its extreme faintness made its form and extent very uncertain. In 1886 the Henry brothers of Paris photographed the Pleiades cluster showing plainly traces of the nebula that could not be mistaken.

In the years immediately following the study of the quality of photographic plates was vigorously pushed forward until in the years 1888 and 1889 the highly sensitive film came into use, after which it became possible to get by the aid of such plates most wonderful details in nebular structure never before dreamed of. The strange and complex back-ground of this cluster as seen in our picture is a good example of the progress in astronomical knowledge, which has been made by the aid of photography in many directions.

A few years ago the best telescopes visually gave only hints of what we now photograph easily with small instruments. In this cluster the stars Alcyone, Merope, Maia and Electra are all

involved in this vast nebulous mass. Alcyone seems to be separated from the others except by a branch from its surrounding nebula that makes a crooked path to the main nebula, involving the other three stars, and which can be traced right through that nebula, as a line of light, to the star Electra. Another faint line of light may be traced through three stars above Alcyone which is nearly parallel to the streak just mentioned. Other similar features can be seen on the original negative but mention of them here is not necessary in order to give the reader a good general idea of the beauty and excellence of photographs that can be made at the present time with instruments adapted to such kind of work.

As we close this description of the Pleiades, we must call attention to the little planet trail of Pompeja, asteroid No. 203, which will easily be found near the right hand lower corner of the plate. Its place is three quarters of an inch from the bottom and about one-fourth of an inch inward from the right hand side. The trail is about one-sixteenth of an inch long, and although rather faint, when once seen, it will afterwards be recognized at a glance. It ought also to be added that the negative from which this plate was made also contained the trail of another asteroid, which was detected on it by the careful scrutiny of Dr. Wilson of Goodsell Observatory. The last named asteroid proved to be a new one, so Dr. Wilson has been credited with the discovery of it. Its place can not be shown on this plate because it is not large enough.

VARIABLE STARS.

J. A. PARKHURST.

VIII.

The current literature of variable stars indicates that interest in the subject is general and increasing. This interest is not diminished by the fact that a prize of $200 has been offered through the medium of the *Astronomical Journal* for the best series of determinations of maxima and minima of variables, made during the two years ending 1895, March 31. The judges who will make the award are Asaph Hall of the U. S. Naval Observatory, S. C. Chandler, of Cambridge, Mass., and Lewis Boss, of the Dudley Observatory, Albany, N. Y.

Journal of the British Astronomical Association.

In No. 2 of Vol. IV. Mr. C. E. Peek of Rousdon Observatory has an article on the long-period variables 4511 T Ursæ Majoris, and 7779 S Cephei, which have been continuously watched at that Observatory since 1886. For T Ursæ Majoris 10 maxima and 10 minima are given. The period adopted is 255.5 days, the deviations from the mean averaging 17 days for the maxima and 16 for the minima. The magnitudes at maximum range from 5.5 to 8.0, at minimum from 12.3 to 13.6.

For S Cephei 6 maxima and 5 minima are given. The mean period is 488 days (Chandler's Second Catalogue gives 484 days), the deviations therefrom averaging 32 days for the maxima and 31 days for the minima. The magnitudes at maximum ranged from 8.0 to 9.7, and at minimum from 11.5 to 13.7 "with a tendency to become fainter at successive minima." The magnitudes are on the Harvard College photometric scale.—

Astronomical Journal.

Three numbers of Vol. XIV have appeared during March and April. Of the 25 articles in these three numbers, 6 are on variable stars.

In No. 313 Dr. L. De Ball of the Von Kuffner Observatory, Vienna, gives details of a maximum of the new variable 1805 V Orionis, occurring near the middle of February, 1891. In No. 315 P. S. Yendell describes his observations of this star during the past winter, showing a maximum of 8.4 magnitude, 1894 Jan. 13. By comparison with De Ball's observations Mr. Yendell deduces a period of 267 days. No minimum of this star has been observed. I was able to follow it till April 5 when it had fallen to about the 12th magnitude. After that date it was too faint to be seen so near the sun. It will be visible in the morning at its next maximum which will probably occur in October of this year, and in the evening at the following minimum which may be expected about 1895, March 1.

In No. 313 Mr. A. W. Roberts, of Lovedale, South Africa, describes his observations of two new short period variables; the first in R. A. $10^h\ 28^m\ 29^s$, Decl. $-57°\ 51'$, having a period of 3.6 days and a range from 7.8 to 8.6 magnitude; the second in R. A. $15^h\ 56^m$, Decl. $-62°\ 31'$ with a period of 2.5 days and varying from 7.7 to 8.7 magnitude.

In No. 314 Mr. Yendell communicates his observed maxima and minima of seven short period variables for 1893, 316 observations yielding 76 maxima and 55 minima.

There are quite a number of variables of this class with periods from 4 to 12 days and light variations of about one magnitude. They are well adapted to the observer who has a field glass and sharp eyes, One of the best for the beginner is β Lyræ which varies from 3.4 to 4.5 magnitude in 12.9 days. It is coming into good position for evening observation and should be compared with the neighboring stars every clear evening. Another good star of this class is 7149 S Sagittæ, which varies from 5.6 to 6.4 magnitude in 8.4 days. It is in R. A. $19^h\ 50^m.6$, Decl. $+16°\ 19'$ (1880). It is marked 10 in Proctor's Atlas, and can readily be recognized if the following stars are charted—

Star	R. A.		Decl.		Mag.	Star	R. A.		Decl.		Mag.
	h	m	°	′			h	m	°	′	
α	19	34.7	+17	44	4.3	γ	19	53.4	+19	10	3.7
β		35.7	17	12	4.4	13		54.6	17	11	5.5
δ		42.0	18	14	3.7	14		58.0	15	42	5.3
ζ		43.7	18	51	5.0	15		58.7	16	45	6.0
S		50.6	16	19		η		59.8	19	39	5.4
11		52.3	16	29	5 3						

If several observers with field glasses would practice on these two stars they might soon be prepared to do valuable work.

In No. 314 Mr. Henry M. Parkhurst publishes maxima and minima and the individual observations of 16 long-period variables. These observations were made with his photometric appliances and the magnitudes expressed on his photometric scale.

Astronomische Nachrichten.

Three interesting articles have appeared lately concerning the new variable T Andromedæ, R. A. $0^h\ 14^m.6$, Decl. $+26°\ 20'.3$ (1855), discovered by Rev. Thos. D. Anderson of Edinburgh. In No. 3213 Professor E. C. Pickering gives measures from the Harvard photographs from 1890, Dec. 29, to 1894, Jan. 2. He deduces a period of 281 days with the photographic magnitudes 9.0 at maximum and 14.5 at minimum (corresponding to 7.5 and 13.0 on the visual scale), and predicts a maximum 1894, March 30. Dr. Ernst Hartwig has a note in the same issue regarding this star, deducing for it a period of 74.4 days and predicting a maximum 1894, March 10. He differs with Professor Pickering by giving an observed magnitude of 8.2, 1894, Dec. 28, only 5 days before Professor Pickering's measure of 12.3 from the photograph, equivalent to about 10.8 visual magnitude.

In No. 3223 Professor Porro of Turin makes a contribution to the subject by giving his observations made in Dec., 1893, and Feb. and March, 1894. For 1893, Dec. 28, he assigns to the vari-

able a magnitude less than 12 (visual). He considers Pickering's period more probable than Hartwig's.

Dr. Chandler suggests as an explanation of the discordant estimates, that the star may be of the U Geminorum type, rising suddenly to a maximum, but this would hardly explain the difference of 4 magnitudes in the estimates of Hartwig and Porro on the same night, 1893, Dec. 28. The simplest hypothesis would be that one or the other erred in identifying the variable. This emphasizes the caution especially needed in beginning this work —*be careful of your identifications.* This star is just coming out of the morning twilight, so that the next two or three months will settle its period. It has been observed here since March 15.

In the same number of the *Nachrichten* Professor Pickering gives a series of measures of 7120 χ Cygni, made with the photometer attached to the 15-inch equatorial at Harvard. The observations are very accordant, the average difference between the observed brightness and that derived from a smoothed light curve being 0.08 of a magnitude. Professor Pickering also mentions the discovery of six variables in the cluster 47 Tucanæ, in R. A. $0^h\ 20^m$, Decl. — 72° 40′, from photographs taken at Arequipa, Peru.

Suggestions for Summer Work.

These are in order now, as Popular Astronomy is not published in July and August. The following stars from the list that have been charted will be suitable for observation, with the apertures given, in June. In many cases a larger aperture will be better in June or will be necessary in order to follow the variable during July and August.

Two Inches Aperture.—U Cephei, S and T Persei, R Lyncis, S Boötis, S Draconis, R Aurigæ, R T Cygni.

Three Inches Aperture.—S and T Ursæ Majoris, S and U Virginis, V Boötis, V Coronæ, S Cephei.

Four Inches Aperture.—R Ursæ Majoris, V and W Virginis.

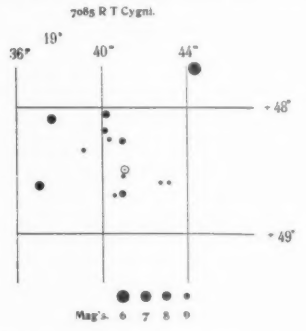
Five Inches Aperture.—R Draconis, U Boötis.

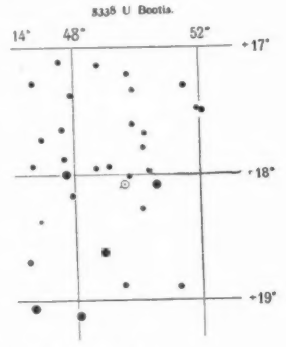
Six Inches Aperture.—W Leonis (?), R Comæ, R Camelopardalis, S Cygni.

Reports.

Mr. W. Dearden of Trinidad, Colo., has been watching 2815 U Geminorum, since its maximum in March, with his 9½-inch reflector. He finds it constant in light, about 4 steps fainter than the companion star *l* given in the May number.

The expected appearance of 3890 W Leonis has been watched for by Mr. Dearden and myself without success. My last observation was 1894, May 7, when the variable was not visible, and therefore was less than the 12th magnitude.





The following variables are charted this month:

No.	Star.	Place for 1900. R. A. h m s	Decl. ° ′	Redness	Magnitude. Max.	Min.	Period days.
5338	U Boötis	14 49 42	+18 6.0	2.7	9.1 — 9.3	12 — 13.6	173.8
7085	R T Cygni	19 40 50	+48 31.9	—	7	11	191

R T Cygni was discovered by Pickering in 1890. Its period is not yet well established. It will reach a maximum probably in June. It was about the 9th magnitude May 6. The 6th magnitude star in the upper right hand corner of the chart will aid in picking up the field which is 3½° north of the 3rd magnitude star δ Cygni.

U Boötis is placed 10° too far north on Proctor's Atlas, fourth edition.

The elements of 3890 W Leonis given in the May number page 401 should read:

1872 Feb. 12 + 394.3 E.

MARENGO, Ill., 1894, May 8.

The soul of man was made to wake the skies;
Delightful outlet of her prison *here!*

* * * *

What involution! what extent! what swarms
Of World's that laugh at Earth! immensely great!
Immensely distant from each others spheres!

YOUNG'S NIGHT THOUGHTS.

PLANET NOTES FOR JULY AND AUGUST.

H. C. WILSON.

Mercury, having been visible in the evening during the last days in June, will in July pass between us and the Sun, being hidden by the rays of the latter during the greater part of the month. He will be at inferior conjunction July 20 at 4^h 28^m P. M. central time. On Poole Bros. map in this number the apparent course of Mercury is shown for the next four months. He will be visible to the eye, however, only during the latter half of June in the evening and the first half of August in the morning.

Venus is slowly receding from us and moving around behind the Sun. Her disc will be 0.76 illuminated July 1 and 0.92 August 30. Venus will pass by Jupiter on the morning of July 20, the nearest approach of the two planets to each other occurring at about 2^h 30^m A. M. On the morning of July 28 at 6^h 13^m Venus will pass very close to the third magnitude star μ Geminorum, the difference of declination of the two bodies at the time of conjunction being only 3′. August 8 at 7^h 45^m A. M. Venus will pass 9′ to the south of another third magnitude star, δ Geminorum. Venus will be in conjunction with the Moon July 30 at 1^h 34^m A. M. and August 28 at 7^h 23^m P. M.

Mars will come into good position for observations after midnight by the first of August, and it is to be hoped that observers will begin early to study the markings on the surface of the planet. It is not necessary to have a great telescope, in order to see them to good advantage. In fact there are some good observers who believe that planetary details can be seen better with small than with large telescopes. We do not subscribe to this belief, but do say that the difference in favor of the large telescope is not so great as to entirely discourage the possessor of a good small one from attempting to add to our knowledge of the planetary markings.

Jupiter and *Neptune* are coming around as morning planets but will not be in good position for observation during the summer. As already noted, Jupiter will be in conjunction with Venus, 51′ north of the latter, on the morning of July 20. Neptune will be still closer to Venus, only 9′ north, July 11, 11^h 54^m P. M.

Saturn will be visible in the early evening but will be pretty low in the west by the time twilight is over. Saturn and the Moon will be in conjunction July 9 at 9^h 11^m P. M. and August 6, 7^h 30^m A. M.

Uranus is making the turn of the loop in his apparent course among the stars and will be almost stationary during July. In August he will move eastward toward the star α Libræ. Uranus will be in conjunction with the Moon July 11 and August 7.

Planet Tables for July and August.

[The times given are local time for Northfield. To obtain Standard Times for Places in approximately the same latitude, add the difference between Standard and Local Time if west of the Standard Meridian or subtract if east].

MERCURY.

Date. 1894.	R. A. h m	Decl. ° ′	Rises. h m	Transits h m	Sets h m.
July 5.....	8 23.4	+16 59	6 16 A. M.	1 28.2 P. M.	8 41 P. M.
15.....	8 11.0	+15 25	5 30 "	12 36.5 "	7 43 "
25.....	7 44.8	+16 30	4 18 "	11 31.2 A. M.	6 42 "
Aug. 5.....	7 46.0	+18 53	3 27 "	10 49.2 "	6 11 "
15.....	8 33.0	+19 04	3 33 "	10 56.7 "	6 07 "
25.....	9 47.4	+15 04	4 27 "	11 31.5 "	6 36 "

VENUS.

Date.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
July 5.....	4 21.5	+ 19 39	2 01 A. M.	9 27.0 A. M.	4 53 A. M.
15.....	5 11.0	+ 21 30	2 02 "	9 37.0 "	5 12 "
25.....	6 01.9	+ 22 26	2 09 "	9 48.4 "	5 28 "
Aug. 5.....	6 58.8	+ 22 17	2 23 "	10 02.0 "	5 41 "
15.....	7 50.4	+ 21 02	2 41 "	10 14.1 "	5 47 "
25.....	8 41.2	+ 18 47	3 04 "	10 25.5 "	5 47 "

MARS.

July 5.....	0 35.0	+ 0 27	11 32 P. M.	5 37.2 A. M.	11 42 A. M.
15.....	0 56.8	+ 2 34	11 06 "	5 19.5 "	11 33 "
25.....	1 17.1	+ 4 28	10 40 "	5 00.6 "	11 21 "
Aug. 5.....	1 37.2	+ 6 18	10 09 "	4 37.4 "	11 06 "
15.....	1 52.8	+ 7 40	9 40 "	4 13.6 "	10 47 "
25.....	2 05.1	+ 8 44	9 08 "	3 46.6 "	10 25 "

JUPITER.

July 5.....	5 20.9	+ 22 43	2 45 A. M.	10 26.2 A. M.	6 07 P. M.
15.....	5 30.4	+ 22 52	2 15 "	9 56.4 "	5 38 "
25.....	5 39.5	+ 22 58	1 44 "	9 26.2 "	5 08 "
Aug. 5.....	5 49.1	+ 23 02	1 10 "	8 52.4 "	4 35 "
15.....	5 57.0	+ 23 04	12 38 "	8 21.1 "	4 04 "
25.....	6 04.4	+ 23 04	12 06 "	7 49.2 "	3 32 "

SATURN.

July 5.....13	12.5	− 4 57	12 33 P. M.	6 16.5 P. M.	12 00midn
15.....13	13.6	− 5 07	11 55 A. M.	5 38.3 "	11 22 P. M.
25.....13	15.3	− 5 20	11 18 "	5 00.8 "	10 43 "
Aug. 5.....13	17.8	− 5 37	10 39 "	4 20.0 "	10 01 "
15.....13	20.5	− 5 57	10 04 "	3 43.4 "	9 23 "
25.....13	23.7	− 6 18	9 29 "	3 07.3 "	8 46 "

URANUS.

July 5.....14	36.2	− 14 52	2 37 P. M.	7 40.0 P. M.	12 43 A. M.
15.....14	35.8	− 14 51	1 57 "	7 00.4 "	12 04 "
25.....14	35.8	− 14 51	1 18 "	6 21.1 "	11 24 P. M.
Aug. 5.....14	36.2	− 14 54	12 35 "	5 38.4 "	10 41 "
15.....14	37.0	− 14 58	11 57 A. M.	4 59.7 "	10 02 "
25.....14	38.0	− 15 03	11 19 "	4 21.5 "	9 24 "

NEPTUNE.

July 5.....	4 53.0	+ 21 06	2 26 A. M.	9 58.5 A. M.	5 31 P. M.
15.....	4 54.4	+ 21 08	1 47 "	9 20.6 "	4 54 "
25.....	4 55.6	+ 21 10	1 09 "	8 42.5 "	4 16 "
Aug. 5.....	4 56.8	+ 21 11	12 27 "	8 00.5 "	3 34 "
15.....	4 57.7	+ 21 12	11 49 P. M.	7 21.9 "	2 55 "
25.....	4 58.4	+ 21 13	11 10 "	6 43.3 "	2 17 "

THE SUN.

July 5.....	6 59.3	+ 22 45	4 21 A. M.	12 04.4 P. M.	7 48 P. M.
15.....	7 40.1	+ 21 28	4 30 "	12 05.7 "	7 42 "
25.....	8 20.0	+ 19 34	4 40 "	12 06.3 "	7 33 "
Aug. 5.....	9 02.9	+ 16 51	4 52 "	12 05.8 "	7 20 "
15.....	9 40.8	+ 13 55	5 04 "	12 04.2 "	7 04 "
25.....10	17.8	+ 10 36	5 15 "	12 01.9 "	6 49 "

THE MOON.

July 1.....	5 04.7	+ 27 39	2 06 A. M.	10 25.8 A. M.	6 55 P. M.
3.....	7 28.0	+ 26 49	4 15 "	12 40.9 P. M.	8 55 "
5.....	9 38.7	+ 17 45	7 05 "	2 43.4 "	10 04 "
7.....11	28.3	+ 4 43	9 47 "	4 24.9 "	10 48 "
9.....13	06.9	− 8 26	12 13 P. M.	5 55.2 "	11 25 "
11.....14	45.3	− 19 25	2 33 "	7 25.6 "	12 08 A. M.
13.....16	30.9	− 26 31	4 50 "	9 03.0 "	1 11 "
15.....18	22.2	− 28 23	6 47 "	10 46.1 "	2 46 "
17.....20	10.8	− 24 42	8 09 "	12 26.5 A. M.	4 50 "
19.....21	49.9	− 16 32	9 02 "	1 57.5 "	7 04 "
21.....23	20.9	− 5 34	9 39 "	3 20.4 "	9 14 "

THE MOON.

	Date.	R. A.	Decl.	Rises.	Transits.	Sets.
		h m	° ′	h m	h m	h m
July	23.....	0 51.4	+ 6 36	10 13 P. M.	4 42.8 A. M.	11 27 A. M.
	25.....	2 31.6	+18 15	10 53 "	6 14.8 "	1 53 P. M.
	27.....	4 31.7	+26 40	11 55 "	8 06.9 "	4 30 "
	30.....	6 51.2	+27 59	1 54 A. M.	10 18.0 "	6 49 "
Aug.	1.....	9 06.7	+20 36	4 33 "	12 25.7 P. M.	8 01 "
	3.....11	03.8	+ 7 47	7 22 "	2 14.2 "	8 49 "
	5.....12	46.8	− 6 04	9 56 "	3 49.0 "	9 29 "
	7.....14	27.1	−17 54	12 22 P. M.	5 21.2 "	10 11 "
	9.....16	12.6	−25 52	2 42 "	6 58.6 "	11 10 "
	11.....18	03.8	−28 36	4 43 "	8 41.7 "	12 40 A. M.
	13.....19	53.5	−25 42	6 11 "	10 23.1 "	2 41 "
	15.....21	34.3	−18 04	7 07 "	11 55.9 "	4 54 "
	17.....23	06.8	− 7 09	7 46 "	1 20.2 A. M.	7 07 "
	19..... 0	36.9	+ 4 52	8 20 "	2 42.2 "	9 19 "
	21..... 2	13.8	+16 40	8 57 "	4 11.0 "	11 41 "
	23..... 4	07.2	+25 40	9 52 "	5 56.3 "	2 13 P. M.
	25..... 6	19.6	+28 36	11 29 "	8 00.3 "	4 29 "
	28..... 8	34.9	+23 11	2 02 A. M.	10 07.4 "	5 57 "
	30.....10	35.3	+11 18	4 52 "	12 00 0 M.	6 50 "

Phases and Aspects of the Moon.

	Central Time.		
	d	h m	
New Moon	July 2	11 45	P. M.
Perigee	" 3	7 40	A. M.
First Quarter	" 9	4 15	P. M.
Apogee	" 17	8 30	A. M.
Full Moon	" 17	4 03	P. M.
Last Quarter	" 25	3 07	P. M.
Perigee	" 31	5 06	P. M.
New Moon	Aug. 1	6 24	A. M.
First Quarter	" 8	4 05	A. M.
Apogee	" 13	1 30	P. M.
Full Moon	" 16	7 17	A. M.
Last Quarter	" 23	11 40	P. M.
Perigee	" 29	12 36	A. M.
New Moon	" 30	2 04	P. M.

Occultations Visible at Washington.

Date 1894	Star's Name.	Magnitude.	IMMERSION Washington M. T.	IMMERSION Angle f'm N p't.	EMERSION Washington M. T.	EMERSION Angle f't N p't.	Duration.
			h m	°	h m	°	h m
July 9	58 Virginis	7	10 29	100	11 30	312	1 01
16	B. A. C. 6628	6	12 58	111	14 00	209	1 02
18	χ Capricorni	5½	14 58	67	16 14	227	1 16
20	B. A. C. 7835	6	7 29	50	8 24	270	0 55
23	B. A. C. 221	6	11 34	15	12 20	279	0 46
26	ζ Arietis	5	10 14	67	11 00	252	0 46
26	B. A. C. 1055	7	14 07	59	15 08	245	1 01
27	χ Tauri	6	13 33	36	14 16	284	0 43
Aug. 13	ω Sagittarii	5	8 42	30	9 47	300	1 05
13	A Sagittarii	5	10 44	61	12 12	252	1 28
16	50 Aquarii	6	11 25	60	12 51	223	1 26
18	20 Piscium	6	8 14	29	9 07	272	0 53
26	47 Geminorum	6	12 04	97	12 49	263	0 45

Elongations of the Satellites of Uranus.

[The diagram shows the apparent paths of the satellites of Uranus during the summer of 1894. The black dots with the numerals indicate the positions of the satellites at intervals of 1 day after each northern elongation. The points marked 0 are those of northern elongation.]

ARIEL.

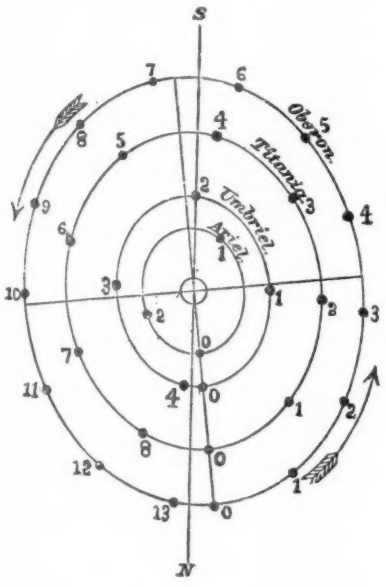
		h	
July	2	10.7 P. M.	N
	5	11.2 A. M.	N
	7	11.7 P. M.	N
	10	12.2 P. M.	N
	13	12.7 A. M.	N
	15	1.2 P. M.	N
	18	1.6 A. M.	N
	20	2.1 P. M.	N
	23	2.6 A. M.	N
	25	3.1 P. M.	N
	28	3.6 A. M.	N
	30	4.1 P. M.	N
Aug.	2	4.6 A. M.	N

UMBRIEL.

		h	
July	5	1.7 A. M.	N
	9	4.3 "	N
	13	7.8 "	N
	17	11.3 "	N
	21	2.8 P. M.	N
	25	6.3 "	N
	29	9.8 "	N
Aug.	3	1.2 A. M.	N

TITANIA.

		h	
July	2	6.7 P. M.	S
	7	3.2 A. M.	N
	11	11.7 "	S
	15	8.2 P. M.	N
	20	4.6 A. M.	S
	24	1.1 P. M.	N
	28	9.6 "	S
Aug.	2	6.1 A. M.	N



OBERON.

		h	
July	7	12.4 A. M.	N
	13	5.9 P. M.	S
	20	11.5 A. M.	N

OBERON, CONT.

		h	
July	27	5.0 A. M.	S
Aug.	3	10.6 P. M.	N

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Central Standard Time.]

U CEPHEI.

Alternate Minima.

		h	
July	5	10	P. M.
	10	10	"
	15	9	"
	20	9	"
	25	9	"
	30	8	"
Aug.	4	8	"
	9	8	"
	14	7	"
	19	7	"
	24	7	"
	29	6	"

ALGOL.

Alternate Minima.

		h	
July	4	2	P. M.
	10	8	A. M.
	16	2	A. M.
	21	7	P. M.
	27	1	"
Aug.	2	6	A. M.
	7	12	midn.
	13	6	P. M.
	19	11	A. M.
	25	5	"
	30	11	P. M.

λ TAURI.

Alternate Minima.

		h	
July	2	4	A. M.
	10	2	"
	17	12	midn.
	25	9	P. M.
Aug.	2	7	"
	10	5	"
	18	2	"
	26	12	M.

δ LIBRÆ.

Alternate Minima.

		h
July	2	2 P. M.
	7	5 A. M.
	11	9 P. M.
	16	1 "
	21	4 A. M.
	25	8 P. M.
	30	12 M.
Aug.	4	4 A. M.
	8	7 P. M.
	13	11 A. M.
	18	3 "
	22	6 P. M.
	27	10 A. M.

U CORONÆ.

Alternate Minima.

		h
July	2	9 P. M.
	9	7 "
	16	4 "
	23	2 "
	30	12 M.

U CORONÆ CONT.

(Alternate Minima.)

		h
Aug.	6	9 A. M.
	13	7 "
	20	5 "
	27	3 "

U OPHIUCHI.

(Every fourth Minimum)

		h
July	1	4 P. M.
	5	1 A. M.
	8	9 P. M.
	11	6 "
	15	2 A. M.
	18	11 "
	21	7 P. M.
	25	4 A. M.
	28	12 M.
	31	9 P. M.
Aug.	4	6 A. M.
	7	2 P. M.
	10	11 "

U OPHIUCHI CONT.

(Every fourth minimum)

		h
Aug.	14	7 A. M.
	17	4 P. M.
	20	12 midn.
	24	9 A. M.
	27	5 P. M.
	31	2 A. M.

Y CYGNI.

(Every fourth minimum.)

July	6	11 A. M.
	12	10 "
	18	10 "
	24	10 "
	30	10 "
Aug.	5	10 "
	11	10 "
	17	9 "
	23	9 "
	29	9 "

Maxima and Minima of Variable Stars.

[From ephemerides by Dr. Loewy in the "Companion to the Observatory," and by Dr. Hartwig in the "Vierteljahrsschrift der Astronomische Geselischaft".]

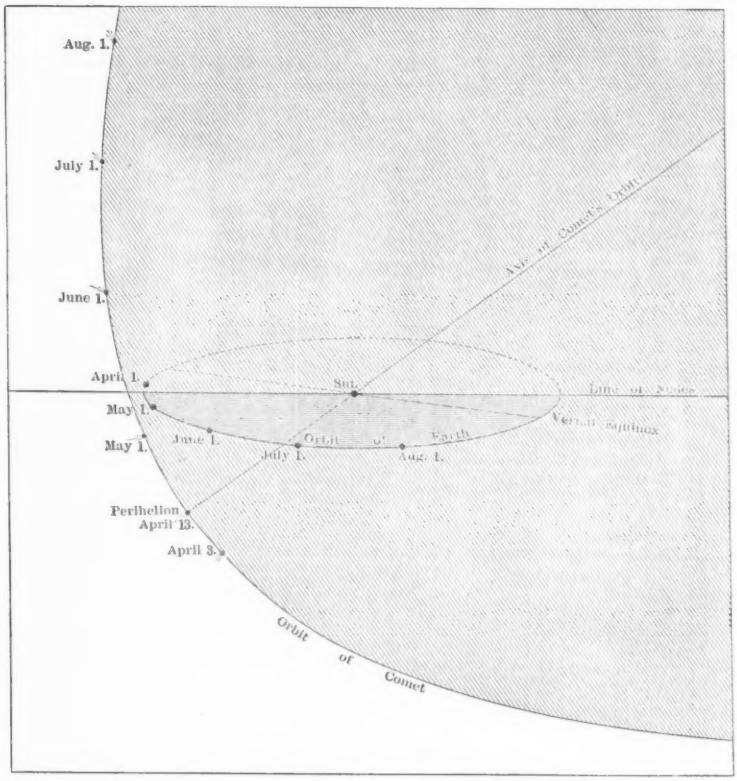
	MAXIMA	MAXIMA	MINIMA
July 1	X Capricorni	Aug. 7 R Vulpeculæ	July 1 T Capricorni
2	R Corvi	7 R Ceti	1 L^2 Puppis
2	R Boötis	7 Y Libræ	5 S Carini
2	R Persei	8 R Ursæ Majoris	10 R Centauri
2	R Geminorum	8 R Pegasi	11 R Scuti
3	U Cassiopeiæ	9 S Ursæ Majoris	14 R Arietis
3	S Scorpii	10 R Carini	14 U Monocerotis
4	R Aquarii	11 U Geminorum	19 R Cancri
4	U Boötis	11 R Virginis	20 R Lyræ
6	S Sagittarii	13 R Arietis	25 S Ceti
10	R Comæ	13 R Lacertæ	26 W Capricorni
10	R Sculptoris	13 U. Libræ	30 U Virginis
18	R Sagittarii	14 T Libræ	30 V Cygni
24	R^2 Libræ	14 S Ophiuchi	31 W Tauri
26	S Vulpeculæ	15 R Scuti	31 R Sagittæ
27	R Leonis Minoris	15 S Arietis	Aug. 2 S Aquilæ
27	Y Virginis	16 S Cephei	5 X Boötis
28	Z Scorpii	16 R Sagittæ	5 S Canis Minoris
29	R Delphini	17 T Ursæ Majoris	7 S Delphini
30	R Scorpii	17 R Pegasi	16 T Herculis
30	V Ceti	18 U Ceti	22 R Leporis
Aug. 1	U Monocerotis	19 V Tauri	29 U Monocerotis
2	W Cygni	25 T Cephei	
3	S Herculis	28 S Cygni	
4	R Lyræ	29 W Scorpii	
5	Z Virginis	30 L^2 Puppis	
5	T Hydræ	30 U Aquarii	
		30 V Ceti	

COMET NOTES.

Denning's Comet *a* 1894.—Our last observation of this comet was obtained on the night of May 3. It was then exceedingly faint, and will probably not be visible, even in the largest telescopes, in June.

Gale's Comet *b* 1894.—This comet which we reported last month as too far south for observation in our latitude has come rapidly north and is now almost out of view from the place of discovery. The orbit is almost perpendicular to that of the Earth, so that it is probably not a periodic comet, and the parabolic elements last received appear to represent the observations fairly well. Mr. Ellery, Government Astronomer, at Melbourne, Australia, has telegraphed the following elements:

$$\left.\begin{array}{ll} T & = 1894 \text{ April } 13.75 \text{ Greenwich M. T.} \\ \varpi & = 324^\circ\ 19' \\ \Omega & = 206\ \ 15 \\ i & = \ \ 87\ \ 15 \\ q & = 0.9849 \end{array}\right\} 1894.0$$



From these elements we have calculated the ephemeris, given in another place, and have indicated the course of the comet on Poole Bros.' map for June. During the next three months it will move northeast through Leo, Leo Minor and Ursa Major into Canes Venatici. It is growing rapidly fainter and will doubtless be invisible before it has completed the course indicated on the map.

The accompanying cut shows the orbit of the comet in relation to that of the Earth. It will be seen that the comet was near perihelion when discovered, that it was rapidly approaching the Earth, that it passed the point nearest to the latter about May 1, and that now it is rapidly receding.

The comet was first seen in northern latitudes by Mr. Douglass at Lowell Observatory, Flagstaff, Arizona, April 26. At Northfield cloudy weather prevented observations until May 3, when the comet was visible to the naked eye as a hazy star of the fifth magnitude. No tail was visible to the naked eye or with an opera glass, but with the 16-inch telescope the tail could be traced 20′ or 30′ from the nucleus. A photograph taken with our 6-inch Brashear camera on May 5 with an exposure of one hour shows very faint traces of a tail extending to the edge of the plate, a little over 6°. Unfortunately the 2½-inch camera happened to be provided with a poor plate and showed the merest trace of a tail in the same time.

Mr. Barnard at Lick Observatory was more fortunate and succeeded in getting a very beautiful picture of the comet with an exposure of two hours and twenty minutes on the night of May 3. He reports a second successful photograph, the copy of which has not reached us at this writing.

This comet was observed by Mr. Douglas at the Lowell Observatory, Arizona, on April 26th, 15^h G. M. T., in R. A. 6^h 50^m, and Decl. 33° 32′ south. He described it as of 5th magnitude brightness; circular, with a central nucleus, and a diameter approximately four minutes of arc, and a narrow tail eight minutes long. On April 28th he found it of the fourth magnitude, and from these and subsequent observations its positions showed it to be gaining somewhat on its ephemeris.

Ephemeris of Gale's Comet, *b* 1894.

Greenwich Midn.		R. A. h m	Decl. °	log *r.*	log Δ	Br.
June	1	11 02.3	+ 38 39	0.1086	9.9869	0.48
	3	07.9	39 21			
	5	13.3	39 57			
	7	18.4	40 28			
	9	23.3	40 56	0.1366	0.0694	0.29
	11	28.0	41 20			
	13	32.5	41 41			
	15	36.9	41 59			
	17	41.1	42 14	0.1642	0.1369	0.19
	19	45.3	42 27			
	21	49.4	42 39			
	23	53.4	42 49			
	25	11 57.3	42 57	0.1912	0.1935	0.13
	27	12 01.1	43 04			
	29	04.8	10			
July	1	08.5	15			
	3	12.1	19	0.2172	0.2415	0.09
	5	15.8	22			
	7	19.4	24			
	9	23.1	25			
	11	26.7	25	0.2418	0.2825	0.07
	13	30.3	24			
	15	33.8	23			
	17	37.3	22			
	19	40.8	20	0.2684	0.3181	0.05
	21	44.4	18			
	23	47.9	16			
	25	51.4	13			

Greenwich Midn.	R. A.	Decl.	log *r*.	log Δ	Br.
	h m	° ′			
July 27	54.9	10	0.2882	0.3497	0.04
29	12 58.4	06			
31	13 01.9	+ 43 02			

Gale's Comet in an Inch-and-a-half Glass.—The ephemeris of Comet *b*, 1894, (Gale) gave its place in the sky and this was laid down upon Klein's Star Atlas. The comet's position was found to be in a continuation of the line joining *o* and ξ Leonis, ξ being almost equally distant from *o* and the comet. About half past eight on the evening of May ninth a small, home-made inch-and-a-half telescope was directed toward that portion of the sky and a nebulous object was seen about where the comet was expected. A diagram of the object and two neighboring stars was made, and at the end of forty-five minutes the object had changed its position in regard to the stars, thus proving that it was the comet. The sky was clear and the star discs were sharply defined. Although the Moon was four days old and shining brightly about thirty degrees from the comet, yet the latter was faintly visible to the naked eye. In the telescope the nucleus appeared as a somewhat elongated condensation just below the center. The coma was circular in general outline, the edges shading off indistinctly into the surrounding sky. No tail was visible.

On May twelfth another observation was taken. In the increased moonlight the comet was smaller and the nucleus not so definite. From the diagrams made on these two evenings the motion was estimated as about seven degrees for the three days. Two days later the comet was again seen. On this evening the sky was hazy although the moonlight was bright. The comet appeared smaller and fainter.

FLORA E. HARPHAM.

Smith College Observatory, Northampton, Mass.

Gale's Comet.—Professor E. E. Barnard has just sent us two fine large positives of Gale's comet taken respectively May 3 and 5. The exposures were over two hours. The long train is beautifully shown in each picture. That of the 3d shows a curious bend near the end, while that of the 5th gives a plain division of the tail for nearly its whole length. These pictures and article about them by Mr. Barnard will appear in the June number of *Astronomy and Astro-Physics*.

Tempel's Periodic Comet.—This comet was found very near the predicted place on the morning of May 9 by Mr. Finlay an astronomer at the Cape of Good Hope. The observed position of the comet was as follows:

May 8.6628 Gr. m. t.; R. A. $23^h\ 45^m\ 21^s.1$; Decl. $-4°\ 51'\ 18''$. This gives as the corrections to Mr. Schulhof's ephemeris $+ 47^s$ in R. A. and $- 1'.9$ in Decl; remarkably small corrections considering the fact that the comet has not been observed since 1878. The comet is described as circular, less than 1′ in diameter, 11 magnitude or fainter, with some central condensation and no tail. It is now at its greatest theoretical brightness but in a quite unfavorable position for observation in the northern hemisphere, owing to the morning twilight in which it must be observed.

PRACTICAL SUGGESTIONS.

44. Mr. Parkhurst says R. Leonis passed minimum Jan. 8, and its maximum is due June. 1; but Klein gives its period as 313 days, and Chandler as 312 days. I would be thankful for any light you may give on the subject. D. F.

Answer: Referring the question to Mr. Chandler we are favored by the following reply:—"By the elements of my catalogue, the minimum took place 1894 Jan. 8 and the maximum will occur 1894, June 1. See the Ephemeris *Astronomical Journal*, 308, pp. 172, 173."

It may be of service to indicate how any desired epoch of maximum or minimum of any star can be derived from the elements of the catalogue

I take this star as an example. The elements of 3493 R. Leonis in the catalogue are:

$M - m = 144$ days.
$M = 1757$ April 21 $(= 2362902.0) + 312.90\ E + 25 \sin (2 : 75\ E + 318°)$
Put $E = 160$
Then add to the principal epoch, or.....2362902.0
The quantity 312.90×160, or.....50064.0
Also $25.0 \sin 38°$, $25.0 \times (+ 0.616)$, or.....+ 15.4
(Since $2 : 75 \times E = 2 : 75 \times 160 = 440° = 80°$)
(and $80° + 318° = 398° = 38°$; and since $38° = 0.616$)
Then maximum, or M is 1894 June 1.4 =.....2412981.4
and since $M - m =$.....144.0

The minimum will be $m = 1894$, Jan. 8.4 $= 2412837.4$

The conversions for Julian calendar dates can be made by the little table given in the introduction to the catalogue before referred to.

45. Do variable stars change gradually from maximum to minimum or is it suddenly between the extremes? D. F.

Answer: Stellar lustre, in general, is affected by endless gradations of change. Long and short period fluctuations are in many cases well known. Secular variations are suspected. There is no known case of a very sudden change from one extreme to another. But in short period changes there are often fluctuations of light when the star is either in a waxing or a waning phase. Miss A. M. Clerke's book, *The Systems of the Stars*, will give much information about the variable stars.

46. I find that the rising and setting of the heavenly bodies as given in POPULAR ASTRONOMY differ from the times given in the Conneticut Almanac in some cases and in others do not. Please explain. C. D. H.

Answer: I think I can explain the discrepancies which you have noticed between our tables of rising and setting and those of the "Connecticut Almanac." The "Almanac" tables have evidently been computed for the longitude and latitude of New Haven. At least, I calculated the times of rising for the three cases which you cite on that assumption and get a constant difference of 8^m which is the reduction from local to standard time at New Haven. Your latitude and that of New Haven are about the same, 41° 18′, while ours is 44° 28′. Bodies on the equator will rise and set at practically the same *local* time at both places but bodies north of the equator rise earlier and set later at Northfield, while those south of the equator rise later and set earlier. The farther from the equator the bodies are the greater the difference. I have a table from which I take the

following corrections to reduce local times of rising and setting at Northfield to those at Guilford:

Decl. of Planet	Corr. to Time of Rising	Corr. to Time of Setting
°	m	m
0	0.0	0.0
+ 5	+ 2.2	− 2.2
+ 10	+ 4.1	− 4.1
+ 15	+ 6 6	− 6.6
+ 20	+ 9.2	− 9.2
+ 25	+ 12.3	− 12.3

For south declination change the signs.

As near as I can determine, Guilford is about 1 minute of time east of New Haven so that the reduction from local to standard time, will be -9^m. The reductions, then, in the three cases cited will be:

	Sun, May 5	Venus, May 15	Mars, May 15
	h m	h m	h m
Local time of rising in Lat. 44° 28′	4 44 A. M.	2 51 A. M.	1 36 A. M.
Reduction to Latitude 41 18	+ 7 "	+ 1 "	− 5 "
Local time of rising in Lat. 41° 18′	4 51 A. M.	2 52 A. M.	1 31 A. M.
Reduction to Standard Time, Guilford	− 9 "	− 9 "	− 9 "
Standard time of rising, Guilford	4 42 A. M.	2 43 A. M.	1 22 A. M.

In computing the times of rising of the planets we have not attempted to be very exact and have taken no account of their motions, but the times are probably all within 1 or 2 minutes. H. C. W.

47. L. H. Ling of Chicago reports the discovery of a new comet in the constellation of Hydra. Is not this Gale's comet?

Answer: It is undoubtedly.

48. The fine photographic view of the Pleiades in the May number of *Astronomy and Astro-Physics* (also plate No. 24) recalls a legend which I have nowhere read and have heard somewhere else than in Chicago, that at the time of our Savior's birth the brightest and best star in the constellation of Virgo had its position in the lap of the Virgin, and that (so runs the legend) when the time shall arrive for the second coming of our Lord, that the same shall take its position as a crown upon the Virgin's head. The idea is very pretty and poetical, and I write to ask whether it receives any color of truth from the annals of astronomical science? H. M. H.

49. I now have a very good Brashear grating and am much interested in spectroscopy. The reversal of the C line in the umbra of the large spot now visible (Feb. 23) is easily seen. I have also secured some fairly good photographs of the Sun showing the large group of spots now visible with a "photoheliograph" of my own make. I am using a 3-inch Jena glass visual objective (by Brashear) and enlarging lens at focus and secure photographs about 2½-inches in diameter. What kind of plates should I use to decrease or avoid halation altogether?

Answer: The best results are obtained at Goodsell Observatory in photography by the use of the Seed non-halation plates. Other companies also make non-halation plates.

50. In "The Natural Genesis" I find the following quotation: When Herodotus was in Egypt, the Egyptians had as now known, observed at least five Sothic cycles of 1,461 years. The priests informed the Greek enquirer that time had been reckoned by them for so long that the Sun had twice risen where it then set, and twice set where it then arose. This can only be realized as a fact in nature by means of two cycles of precession, or a period of 51,736 years." The time of Herodotus was 484 B. C. and later.

What I wish to ask, is whether or not it is positively known that the Earth changes its inclination in relation to the stars simultaneously with the change of the inclination of its axis which causes the precession of the equinoxes. Or does the axis change its relative position to the Earth as well as to its orbit?

H. D. C.

Answer: The statement preceding this query contains several points which we have not space to allude to now. It may be done latter. We have been accustomed to put the final query in a little different language although the meaning is the same. Does the line we call the terrestrial equator and the points we call the poles of the axis of the Earth change, or are they fixed in position on the Earth's surface? The opinion that the axis within the globe is not in an absolutely fixed position with reference to points on the Earth's surface is, I think, gaining ground though it can hardly be said to be generally accepted as a doctrine of the terrestrial sphere. An article will soon be published setting out the nature of this question, its mode of study and the results so far reached.

51. At what hour should one look for a star, whose position is known in right ascension and declination? We will take for instance Capella whose R. A. is $5^h\ 8^m$ and Decl. 45° 52′ (Webb 1880). Supposing that a person had an equatorial and had set his R. A. and Decl. circles as above, at what hour should he expect to find Capella?

Answer: The declination circle should be set as suggested whenever the star is to be observed, but this is not true of the right ascension circle (or more properly the hour circle). The setting for this circle at any given time is the difference between the star's right ascension and the sidereal time. If the sidereal time is less than the right ascension the star is past the meridian, if greater it has not yet reached the meridian. It is very desirable that the observer should have a sidereal clock or chronometer to aid in determining this setting; if such a timepiece is lacking it is not difficult to obtain sidereal time from mean time when certain necessary data are given. The following table gives the difference between mean time and sidereal time at noon for each fifth day of June, sidereal time being the faster.

Date	Sid. Time of mean Noon.			Date	Sid. Time of mean Noon.		
	h	m	s		h	m	s
June 5	4	56	36.54	June 20	5	55	44.92
10	5	16	19.33	25	6	15	27.71
15	5	36	2.12	30	6	35	10.51

From this table it is evident that sidereal time gains $3^m\ 56^s.56$ per day and $9^s.86$ per hour on mean time. It is thus possible to calculate the difference between mean time and sidereal time for any hour of any day. To obtain sidereal time add this difference to *local* mean time.

52. Kindly give the name of the best history of astronomy which is earlier than than that written by Miss Clerke.

E. H. MC L.

Answer: History of Physical Astronomy from the earliest ages to the middle of the 19th century by Robert Grant, F. R. A. S. This book was written in 1852 and published by Robert Baldwin, Paternoster Row, London. It can be imported by any bookseller.

53. Can you refer me to any authority where I may find the proper catalogue number of the nine named Pleiades? R. H. A.

Answer: We take the following designations of the Pleiades stars from Bessel's list in "Abhandlungen von F. W. Bessel," by Engelmann, Leipzig, 1876, and from Heis' "Catalogues; Atlas Coelestis."

We have no means at hand of determining when Atlas and Pleione were added to the ancient group.

Bessel's Letter.	Name.	Flamsteed's No.	Heis' No.	Bayer's Letter.
η	Alcyone	25	31	η
b	Electra	17	24	...
c	Maia	20	27	...
d	Merope	23	28	...
e	Taygeta	19	26	*g*
f	Atlas	27	36	...
g	Celœna	16	23	...
h	Pleione	28	35	...
k	Asterope	21	...	...
l	.....	22	...	

54. I desire a book that will tell me how to construct and to use a small telescope. Please give information. W. C. P.

Answer: We do not know of any one book that will furnish the information asked. In regard to the care and use of telescopes a book called The Amateur Telescopist's Hand-book by Frank M. Gibson and published by Messrs. Longmans, Green & Co., 15 East Sixteenth St., New York City is just out and would give some of the information wanted. A brief notice of the book was given in our last issue.

GENERAL NOTES.

Attention is called particularly to the publisher's notices at the end of this number.

We are not satisfied with the illustration that we have been able to give so far. It has been good in kind generally, but we want to give more of it. We can and will do this if our subscription list for the coming year is much increased.

Note for Beginners about Motion in the Sky.—In the celestial sphere there is north and south but not east and west, only direction of motion. The bodies which we watch in the dome of the sky are moving in curves, and the direction of their motion must be that of one of the two screw motions, either with the hands of a clock or against them. Thus, if in northern latitudes we follow the stars of the big dipper, they seem sometimes to be going toward the east point and sometimes toward the west point of the horizon, but the circular or screw motion remains always unchanged in direction.

If we face the south and place in imagination near the Sun, Moon and planets a clock dial with the "XII" that is the zero up toward the zenith, we find that

the Sun and the Moon are moving against the hands of the dial. The planets when advancing, move in the same direction, but when retrograding they go with the hands. Since astronomers are agreed in calling the apparent annual motion of the Sun among the stars an eastward motion, we may conclude that in the northern hemisphere counter clock-wise motion is eastward motion and clock-wise motion westward.

The Earth, as well as other bodies of the solar system, may be projected upon the celestial sphere. If we think of the Earth and the Sun as projected at the same time, both these bodies move eastward among the stars, even though at a given instant they are going in opposite directions in regard to the west point of our horizon. These two motions are of course opposite as regards right and left but they are both eastward throughout the year, since the screw motion in both curves iscontinuously counter clock-wise. MARY E. BYRD.

Suspected Variable near ν Scorpii.—Mr. W. E. Sperra of Randolph, Ohio, has been observing since January a star in the field with ν Scorpii which seems to vary. It can be identified if the following stars are charted:

Star.	Co-ordinates from ν		Mag.
	m	′	
var	−1.8	+ 2	
a	−1.4	− 38	8.5
b	−2.1	− 7	9.5
d	−3.5	− 5	6 5
e	−2.8	− 17	9.8
f	−3.4	− 19	9.7
g	−1.7	+ 7	10.0

It seems to vary with a short period between 8.5 and 9.3 magnitude. It is in good position for evening observation, and will bear watching.

J. A. PARKHURST.

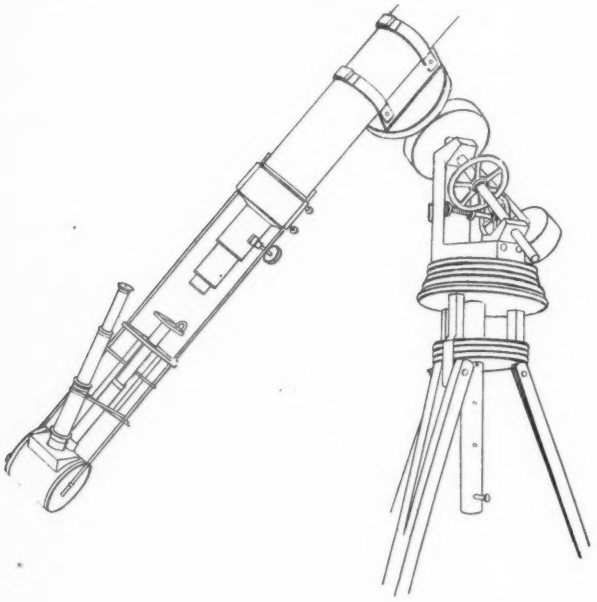
Professor Glassenapp's Double-Star Measures in 1892.—The measures of double-stars made by Professor S. Glasenapp at Abastuman in 1892 have just appeared in a handsomely printed volume issued from the press of the Imperial Academy of Sciences of St. Petersburg. The observations include about six hundred pairs, principally from the Dorpat catalogue, each star being observed as a rule on two nights. The other pairs measured are from the OΣ and β catalogues. The measures are excellent, and the stars judiciously selected considering the aperture of the equatorial.

It is to be regretted that this work could not have been continued, as the atmospheric conditions were found to be very favorable both as to the steadiness of the air, and the number of working nights. The elevation is some three hundred feet higher than Mt. Hamilton, and in point of latitude is much more favorably placed for observing south of the equator than any of the other Russian Observatories. From the amount of work done in the comparatively short time the Observatory was in active operation, it is evident that Professor Glasenapp made good use of his opportunities. Visitors to the Russian exhibit at the World's Fair will recall the beautiful photographs contributed by Professor Glasenapp of the picturesque Mountain Observatory at Abastuman. S. W. B.

Double Star Measures Near H 3950.—The faint pair of stars, near H 3950, referred to by Mr. Sprague in the May number of *Astronomy and Astro-Physics,* (p 417) was first noted in the low-power sweeps at Madison (*Pub.*

Washburn Observatory Vol. II), and subsequently measured by Comstock in his review of those stars (Vol. VI). It is much too wide in distance and too faint in magnitudes to be of any interest as a real double star. S. W. B.

Small Telescope with Spectroscope.—In a note on "Observations of Sun-spot Spectra" published in the February, 1892, number of *Astronomy and Astro-Physics*, the attention of amateurs was called to the valuable contributions which they can make to Astro-Physics with simple apparatus and at a moderate outlay. Some time ago I obtained from Mr. J. A. Brashear of Allegheny, Penn., an excellent 2-inch Rowland diffraction grating of 14438 lines to the inch, and the following description of its mounting and the completed instrument may be of service to some other amateur with moderate means.



The illustration, taken from a photograph by myself, represents the eye-end of the telescope tube with spectroscopic attachment and spectroscope in position, the telescope is mounted equatorially with slow motion in R. A.; the object glass is 3-inches aperture made of Jena glass; the tube is of polished brass and has near the eye end a revolving ring or collar 2 inches in length and about ¼ inch thick containing apertures into which the brass rods of the spectroscope are inserted, also the necessary adjusting screws for clamping the rods and collar to the tube; thus the spectroscope may be rotated around the optical axis of the tube and clamped tightly in any position. This tube with its attachment was designed and manufactured by Mr. J. A. Brashear, (as was also the object glass), who is one of the finest opticians and instrument makers in the country. The grat-

ing box I had turned from a piece of very hard wood; it is 4¼ inches long and 3¾ inches diameter on the outside, and 3¼ inches internal measure (this large size was necessary on account of the 2 inch grating; a smaller grating would be better on the same size telescope); the ends are removable and to one of them the grating mounted on a T piece is affixed; the grating or prism may be rotated on its axis by means of a small brass button connected by a couple of gear wheels. Two brass rods 21 inches long and five-sixteenths inch diameter are securely fastened by screws to the end pieces of the grating box, the distance between the rods being about 4 inches. The collimator and observing telescope are each about 10 inches long with object glasses of one inch aperture (smaller ones would answer just as well and would be preferable being lighter, but these were used as I had them on hand) these are inserted into holes accurately bored in the grating box, so that the angle between them is about 28 degrees. A small frame-work of hard wood fastened to the brass rods serves to hold the collimator in place, also the observing telescope which is secured to it by means of a brass support.

The entire instrument is very quickly and easily attached to the telescope, by simply inserting the rods into the apertures in the collar the proper distance and clamping; the finer adjustments to the focus, etc., are made by rack-and-pinion movement to the collimator tube. When all the necessary adjustments are made, the Sun's image brought accurately to focus on the slit plate and the collimator and observing telescope moved until the lines are clear and sharp,—the chromosphere lines, reversals in and near large sun-spots, and the various prominences are very readily seen; for viewing the prominences the great C line in the second order is generally used, the images in the F line being not as distinct.

Solar spectroscopy is indeed a most interesting and fascinating study and it is hoped the above short sketch of the instrument put together at moderate expense may be of use to some other amateur desiring to obtain a knowledge of the new astronomy.

DAVID E. HADDEN.

ALTA, Iowa, May 9th, 1894.

Auroræ, Sun-Spots and Earth Currents.—I now have more complete information respecting the outbreak previously mentioned on Feb. 22, 23 and 25, and in regard to those of April 12-14 and March 30th, etc. The following are some of the points that may be of interest:

There were some premonitions of an aurora on Feb. 21st, sporadic displays being reported from various localities in this country and Europe. Magnetic perturbations and disturbance of the telegraph lines by Earth currents began to be felt on this date. On Feb. 22d the aurora became bright near the Pacific coast of North America extending unusually far south in California, Arizona and New Mexico, and Earth currents affected the telegraph lines to a noticeable extent west of Chicago exclusively. Mr. Finn of the Western Union Company says that he can find "no record whatever of the presence of Earth currents east of Chicago on Feb. 22d." On Feb. 23d, however, both Earth currents and aurora appear to have been strongest near the Atlantic coast although generally felt on the North American continent. On Feb. 24th, there was nothing special noted either in regard to aurora or Earth currents as far as reports are at hand. But on Feb. 25th there was very strong disturbance of the telegraph circuit extending northeastward from New York City, a distance of about six hundred miles, at 3:30 A. M. and between 8:30 and 9:30 A. M. Reports now at hand from Ekatrainenburg in the Ural mountains, and from Irkutsk, Siberia, in the northern hemisphere and from Australia and Tasmania in the southern hemisphere show that there was a splendid aurora which seems to have been at its maximum at the very time on Feb. 25th at which the Earth currents above mentioned were strongest. It will be extremely interesting when the Greenland observations come to hand to learn whether there was concentration of the auroral effect in the direction of the meridian of Asia and Australia, it being possible to determine this only by the aid of reports from localities where observations were not hindered by daylight throughout the entire twenty-four hours. The relation of

the geographical distribution of Earth currents to the corresponding distribution of the aurora, and the concentration of the aurora particularly, at certain longitudes and latitudes is a subject that deserves careful study. A notable instance of a similar localization in longitude to that above described appears in the case of the aurora of April 12-14, the Earth currents accompanying which, however, did not disturb the telegraph lines in such manner that their distribution could be traced without much greater care than it was possible to exercise at the time. The aurora itself, however, was a conspicuous display on the North American continent on the night of April 12th, only very faint and evanescent auroral glows being seen on April 13th and 14th on this side of the Atlantic. In Europe, on the other hand, the display did not become conspicuous until the night of April 14th when it was very widely seen.

It will be observed that both in February and April there was a progression eastward of the maximum phase on successive nights. It is possible that this may have been merely fortuitous, it is a point however worth keeping in mind for the purpose of obtaining further evidence.

The great magnetic storm and aurora of March 30th appears to have been more evenly continuous and more uniformly diffused in longitude, its most striking peculiarity being its forming a belt whose center was in unusually low latitude both in this country and Europe. The recurrence of this aurora at the usual 27¼ day interval on April 25th as seen at Lyons was marked by the rare phenomenon of the appearance of streaks resembling ordinary auroral streamers in shape and arrangement, but looking like shadows across the diffused luminous background of the aurora. There were no streamers of the usual kind at the time, so that it could not have been the effect of contrast of dark spaces intervening between such streamers. I have read descriptions of something of the sort as having been seen in the Arctic regions, but have never met with it before.

As appears from the above descriptions an effort is being made to compare the records of Earth currents affecting the telegraph lines with the distribution of the aurora. Through the courtesy of Gen. Eckert president of the Western Union Company, the matter has been referred to their electrical engineer, A. S. Brown, and such measures as are likely to be most practicable are being taken in order to secure the requisite memoranda for such purposes of comparison. The results already obtained, which are merely hinted at rather than fully described, are such as to stimulate a very decided interest. M. A. VEEDER.

BOOK NOTICE.

Elementary Meteorology by William Morris Davis, Professor of Physical Geography in Harvard College. Messrs. Ginn & Company, Boston, Publishers, 1894, pp. 355.

Mr. Davis has written a timely and a much-needed book on the subject of Meteorology. The earlier work by Professor Loomis and the recent and scholarly study by the late Professor William Ferrel in some branches of meteorology have awakened interest in this science and in some degree, prepared the way for a more complete treatise on the elementary principles of the branch like the work now before us. The table of contents is given in fourteen chapters, each of which is broken into subject paragraphs numbered and titled in heavy-faced letters and figures, making the text a useful one for class work, and equally convenient for popular reading. An idea of the scope of the book is obtained readily from the titles of its chapters, as follows: The general relations of the atmosphere; extent and arrangement of the atmosphere about the Earth; the control of atmospheric temperatures by the Sun; the colors of the sky; the measurement and distribution of atmospheric temperatures; the pressure and circulation of the atmosphere; the general classification of the winds; the moisture of the atmosphere; dew, frost and clouds; cyclonic storms and winds; local storms; causes and distribution of rainfall; weather and climate. Many of the chapters are illustrated either by cuts of instruments used in observation, or to show graphic results pertaining to some features of the science that may be best presented in that way.

Professor Davis has worked out his subject matter in an admirable way. It seems to us that this would also be an excellent reference book for any one whose duty it is to teach the elements of physical geography for it will put into the instructor's hands a great many facts that would aid in explaining much hat the ordinary text-book does not give.

PUBLISHERS' NOTICES.

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MAP OF THE

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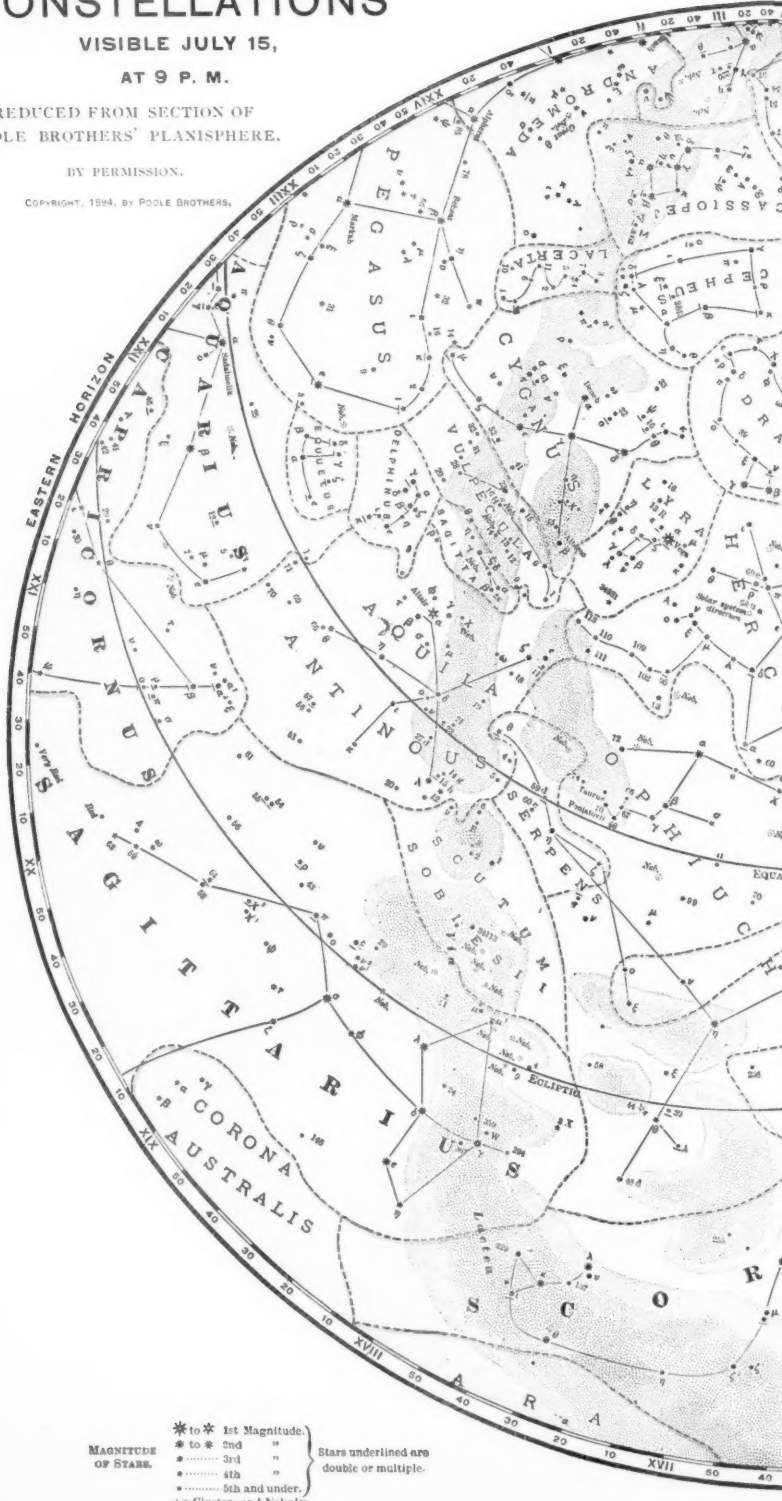

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Vindemiatrix
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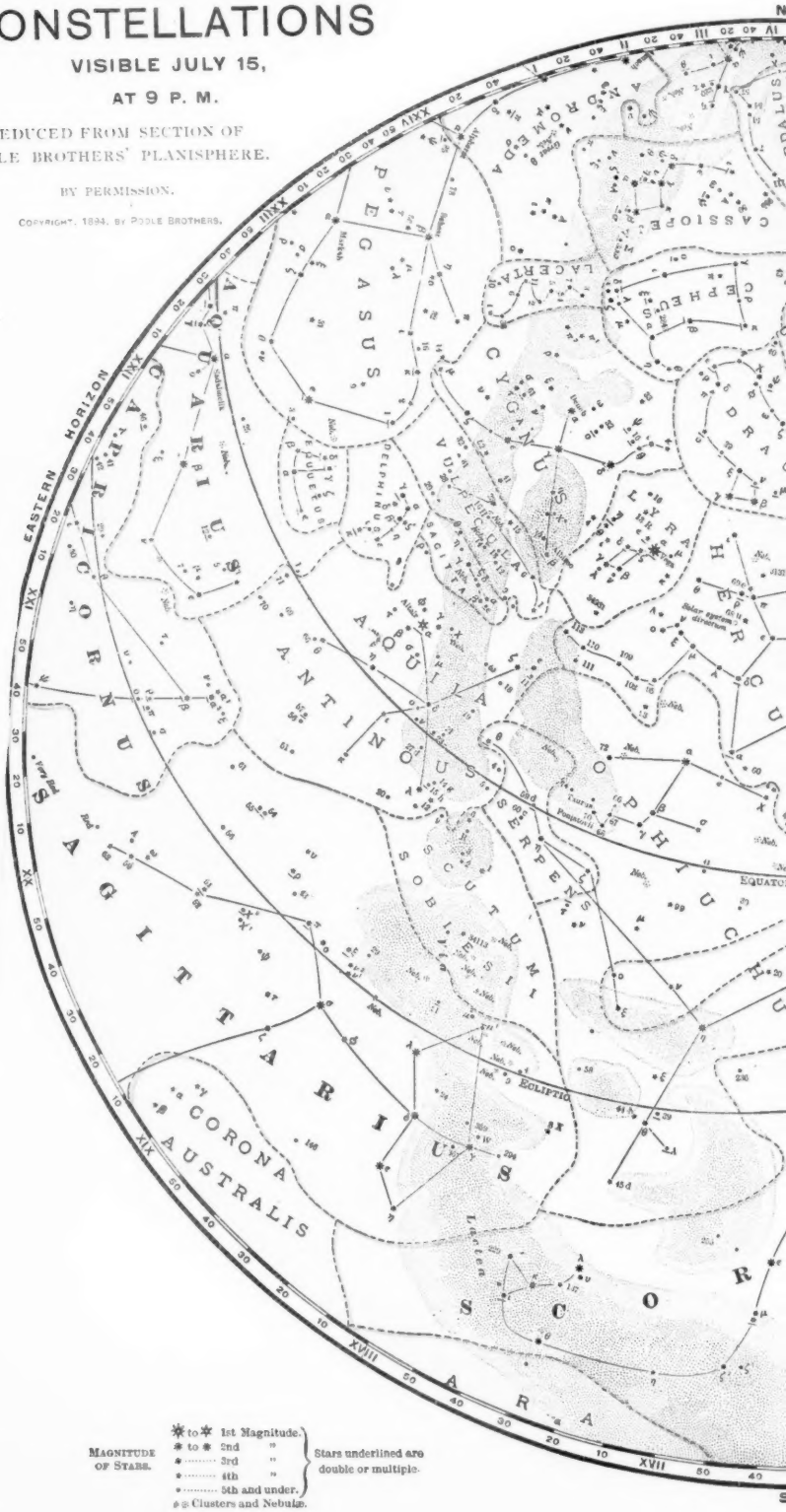

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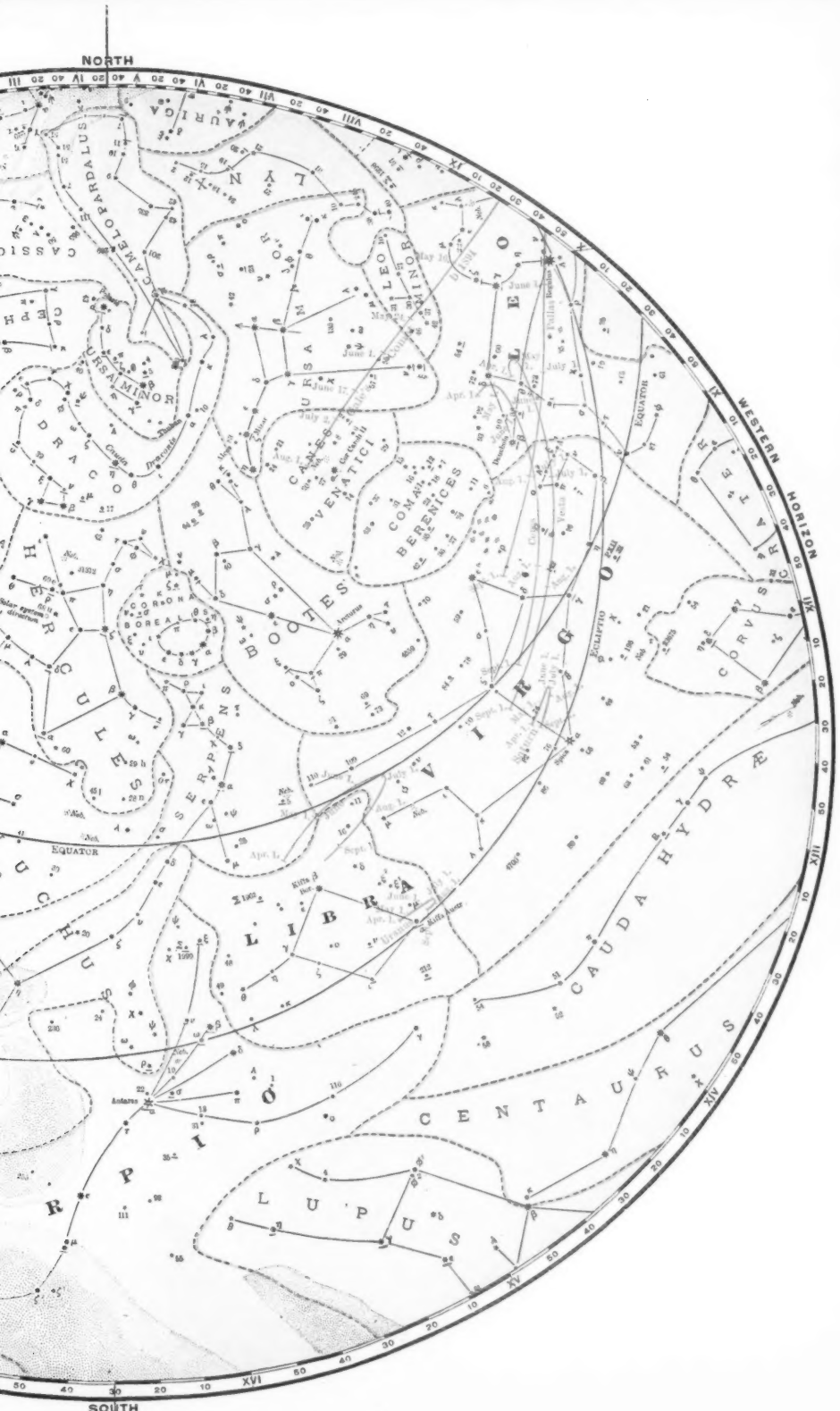
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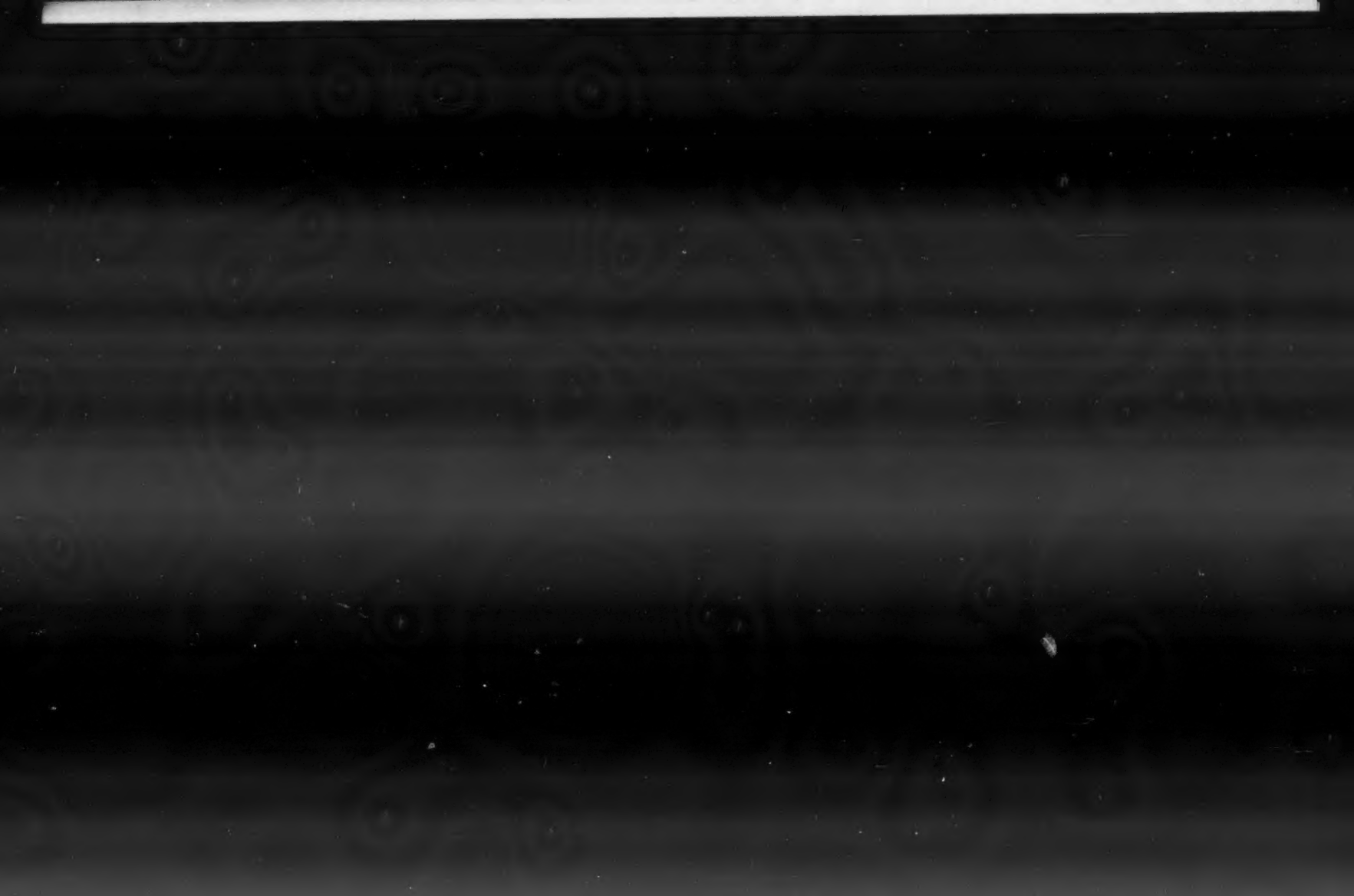

PUBLISHERS' NOTICES.

The accompanying Star map, title page and indexes, completes Vol. I of POPULAR ASTRONOMY.

About one-fourth of the subscribers to the first volume have responded to the early request made respecting continuance and increase of support. Some have renewed, and sent in new names also.

The Poole Star Maps, and Professor Upton's splendid articles on Constellation Study, are alone worth the price of Volumes I and II. These excellent helps for teachers of Elementary Astronomy can now be procured at $2.50 per volume, in pamphlet form. They should be ordered early, for teachers' reference, and the High School library.

It is especially requested of *all subscribers*, who have not already done so, that they promptly inform the publisher of this magazine if they desire its continuance for Volume II., that its September number may be mailed to all by the *20th of August.*

Poole Brothers, of Chicago, the publishers of Poole Brothers' Celestial Planisphere and Handbook, will soon bring out a new, large Map of the Moon. Some notice of this was given in our June issue. As the work progresses, under the skillful hand of Mr. Colas, we have become more and more interested in it, and have spent much time in examining its details, compared with those given by the standard authors. They are very accurate

In binding Volume I, the accompanying Star Map should be placed immediately after the one in the June number for July 15, and the index by months should follow title page, and the general index be placed at the end of the volume.

The coming year may be one of large results, for those who want to advance in the study of Astronomy, if such students are willing and anxious to work for it. We call attention, again, to the great advantage of associated study, in some particular line, if no other or better plan can be devised. Three or four persons, formed into a class, with a persistent purpose, can accomplish surprising things, by self-instruction in evening hours, without the apparent loss of valuable time. How much better is it to use some evenings in this way, than to devote so much time, as many people do, to *Society.*

It is in our plan to give soon some hints on courses of reading. This would have been done earlier, but for the want of space. The many interesting themes that have crowded upon us during the last year, have made it hard to keep up a useful variety and still be thorough, elemental, and up to the latest knowledge in it all. We believe we can do better in the year to come.

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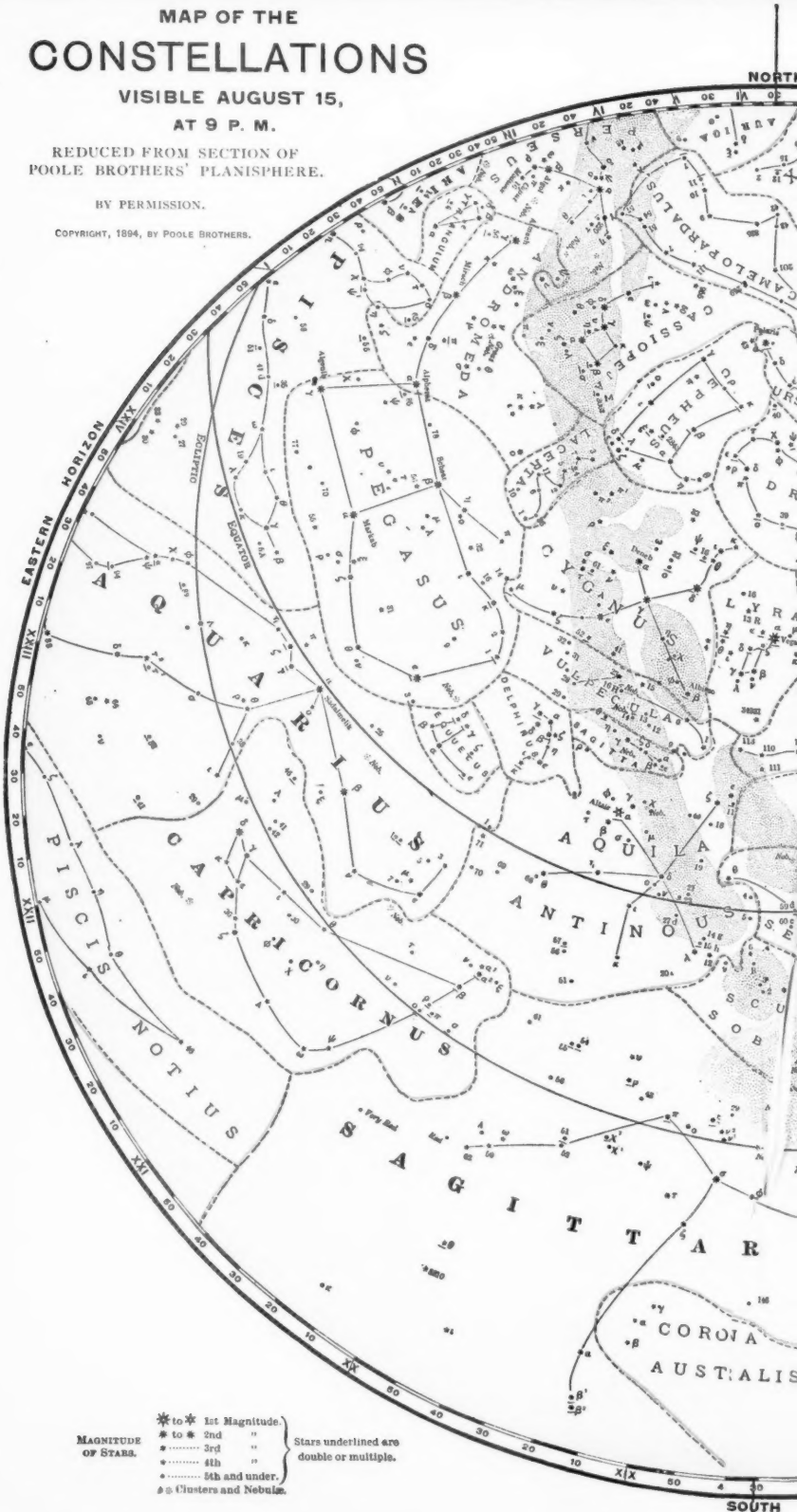

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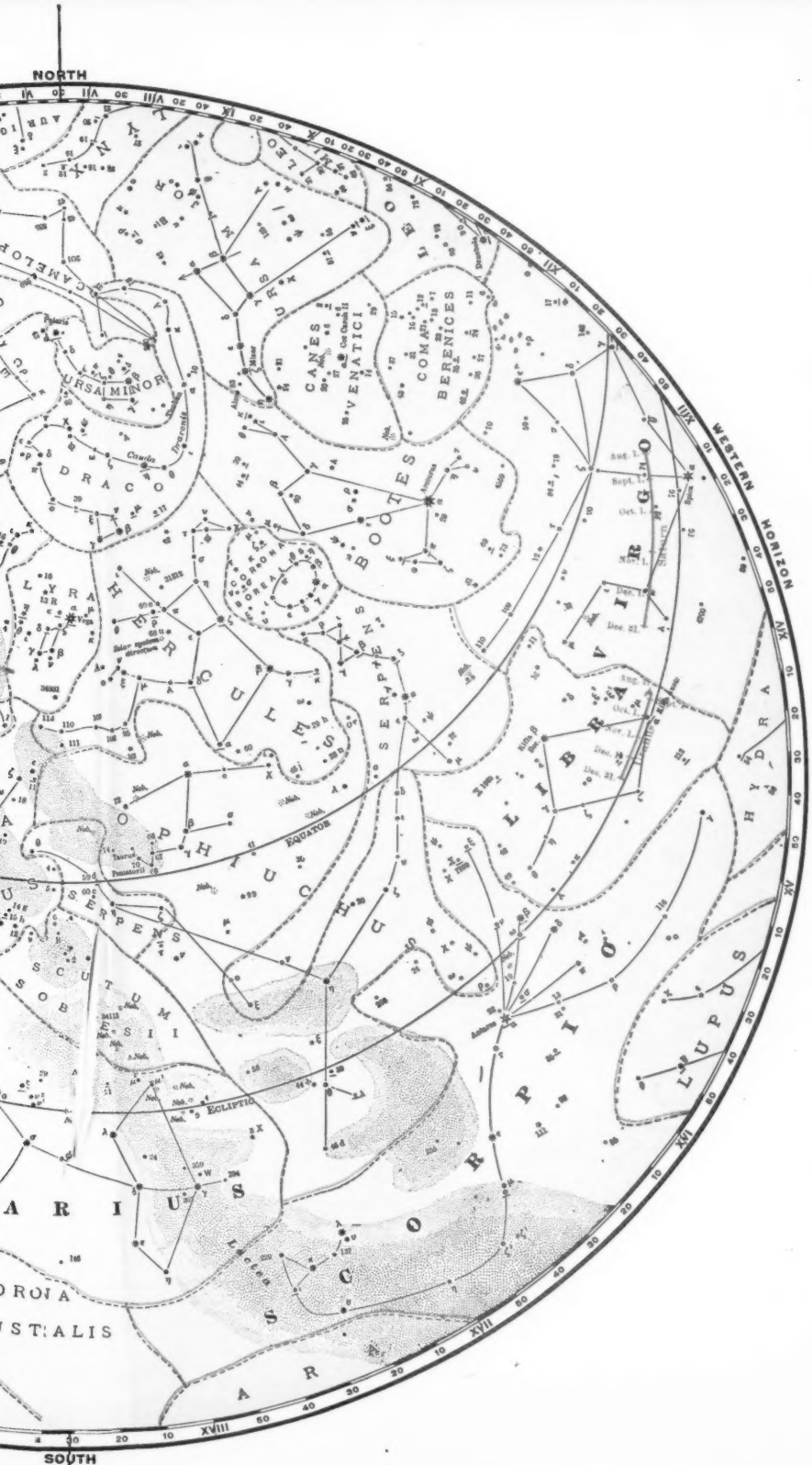
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